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Television Lighting Routines

By WILLIAM R. AHERN

The lighting installation of NBC Studio 8H features convenient facilities for setting up the many and varied lighting routines required by today's television shows. Efficient operation of these facilities reduces studio usage for lighting purposes, and consequently increases the number of shows which can be staged each week. This paper describes the installation, and provides a documentary account of the process of lighting a typical dramatic show.

In the short space of less than a decade, television lighting has gone through a complete revolution. The older camera tubes required extremely high light levels of 800 ft-c or more. Terrific heat from the lights poured onto actors and scenery, and was accepted as a normal part of the television operation. Little attention could be given to the nuances or delicacies of lighting when the main problem was one of getting enough light. The photographer who came to the studio for some publicity shots often preferred to set up his own lights to produce the type of picture his public had come to expect. Today, the same photographer is running into trouble at the other end of the scale. Quality is excellent, but light levels are getting too low. On finding a low key or dark scene, the photographer is now likely to ask, "Is there going to be more light in here? I've got to get a picture."

Presented on October 7, 1953 at the Society's Convention at New York, by William R. Ahern, National Broadcasting Co., 30 Rockefeller Plaza, New York 20. (This paper was first received Dec. 9, 1953, and in revised form Jan. 14, 1954.)

It would seem, offhand, that the lower light level means chiefly that shows can be lighted quicker and with less trouble; but progress in lighting has steadily improved the pictures in their quality. We are now portrait painting with light. We are pinpointing areas and there are close-ups to take care of, just as in motion-picture work. Actually more careful lighting and, consequently, more lighting time are required to give the type of picture at home that the public has come to expect, and that the client has a right to expect.

The client has two good reasons for wanting to keep lighting time down. One is the direct cost to him for the lighting director's time, the electricians, and so forth. The other is less obvious. If a show ties up a studio for two days (one day to light the show, and another for rehearsal and air time), the studio is out of use for other shows. This, of course, means that the TV station or network must have more studios, and hence make greater charges to clients.

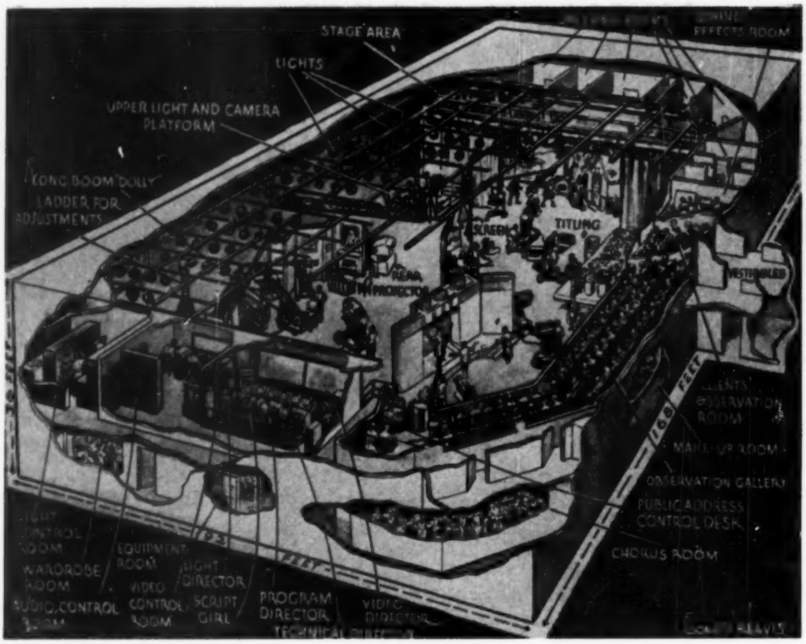

Fig. 1. Sectional view of NBC Studio 8H.

There are two ways of keeping lighting time down. The first is to provide complete and convenient facilities in the studio to minimize the amount of time it takes to light a show. However, caution is necessary. It is easy to develop an elaborate system that seems operationally efficient, but proves to be complicated, unreliable, and wasteful of maintenance time and labor. It is necessary to strike a balance. The second way is to apply the techniques or tricks of the trade, that lighting directors have developed over a period of years. Both ways will be demonstrated. The facilities at NBC's Studio 8H in New York, which is one of the newer studios, will be described. Then, the lighting of a typical show will be reviewed. This will be presented chronologically, step by step, to show how the lighting was performed.

Lighting Facilities

Figure 1 is a cutaway view of Studio 8H, which shows the position of the lighting switchboard. With the lighting switchboard elevated in this position, the electrician can look out over the scenery in the whole studio and see where his lights are, and which ones are on. The control room, also elevated, is to the right in the middle of the picture. The video engineer and the lighting director sit together at the righthand side of the control room. Note that the studio is approximately 92 ft by 168 ft.

Some of the lighting equipment in the studio is shown in Fig. 2. There are lighting pipes hanging on steel cables which run over sheaves in the ceiling to counterweights on the side, just like a stage. In television there is a real marriage of motion-picture tech-

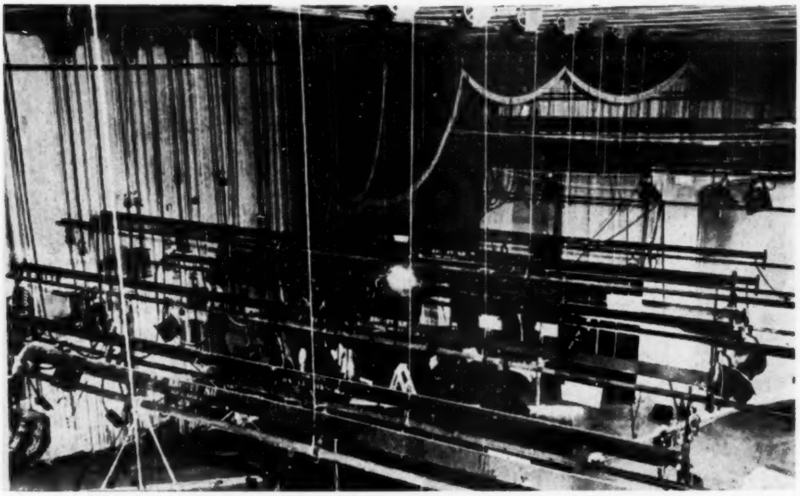

Fig. 2. Looking down through lighting pipes.

niques with stage techniques. The material above the hanging clamps on the lamps resembles stage techniques, with the counterweights, the steel cables, the lighting pipes that go up and down, and so forth; while below are Fresnel-type spotlights, barndoors, scrims, and so forth, as in motion pictures. The lighting pipes in this studio are spaced about 4 ft apart, run all the way across the studio, and can be raised to a height of approximately 35 ft.

One of the first things done in lighting a show is to set the height of the lighting pipes. In this studio there have been Westerns with live horses and very high scenery, for which the pipes were pulled up about 30 ft in the air, against the ceiling, to give the necessary clearance. In most dramatic shows, the sets are about 10 ft high, and the pipes are brought down to about 12 ft from the floor. Manila ropes operate the counterweights from the floor to change the height of the pipes.

On each lighting pipe is a raceway from which the lighting outlets hang. The raceway is fed from a multiconductor cable that loops down from the ceiling. The outlets, or pigtails, or lighting receptacles, are on 2-ft leads, and are spaced about 5 ft apart. A lamp can be hung and plugged in at any outlet with no waste of time to find a cable or jumper. In this studio there are approximately 425 of these outlets, to practically eliminate the time consuming procurement and use of extension cables. About 24 of these outlets are spread around the floor of the studio. Also, all outlets are numbered to identify circuits back at the switchboard.

Figure 3 shows the distribution section of the switchboard which provides for choice of interconnections between outlets in the studio and dimmers or switches in the control section of the board. On the right is a patch-cord type of interconnection where each plug protruding above the horizontal surface is connected to a retractable cable that eventually feeds an outlet in the studio. On the vertical surface are the receptacles which are permanently wired to the various dimmers

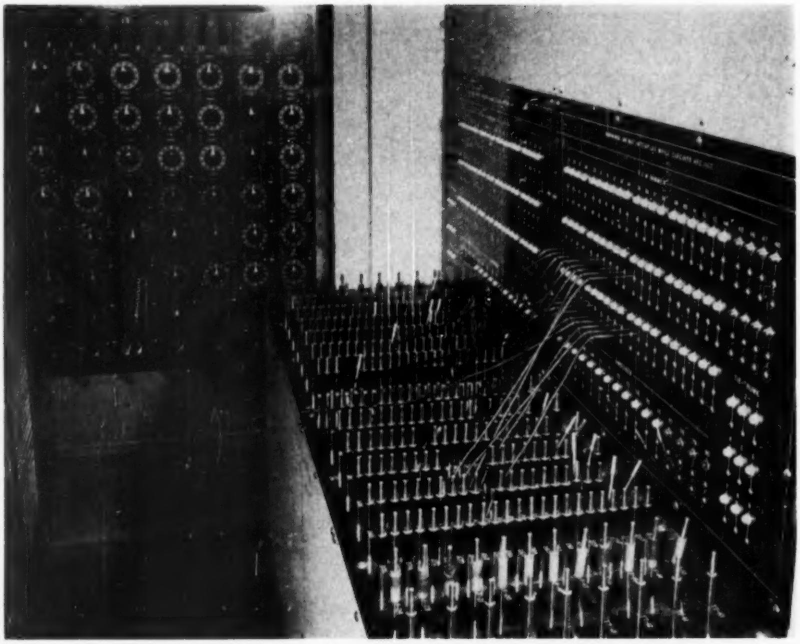

Fig. 3. Interconnection or distribution section of lighting switchboard.

Fig. 4. Control section of lighting switchboard.

and switches in the control section of the switchboard. This permits complete flexibility in energizing an outlet or group of outlets from any dimmer. In the background is another type of interconnection. Each one of those knobs in its square panel represents an outlet in the studio. By turning the knob pointer to the number of the desired dimmer and pushing the knob in, that outlet is then connected to the proper dimmer. This is a rotary selector type of operation for getting the circuits in the studio through to whatever dimmer is desired.

The operating position of the board is shown in Fig. 4. On the right is a vertical-type board with the various dimmer handles protruding. The electrician is at a console-type board. On both boards, dimmer handles are mechanically arranged so that they can be worked in groups or individually. Also each dimmer has a load meter to preclude circuit breakers from killing lights through overloads. The object in the foreground is a picture monitor for the electrician's use. If, for instance, an actor coming into a room snaps the light switch on the wall, the electrician can time his cue perfectly by watching the picture on the monitor. A headset keeps the electrician in direct two-way contact with the lighting director in the control room.

In this studio there are about 1500 amps available. Approximately 120 dimmers are used to give the flexibility needed to light a show in a minimum of time.

Lighting Practice

Having described the equipment, we may proceed to the lighting of the September 10th *Martin Kane* show, which is on from 10 to 10:30 E.S.T. on Thursday nights.

Approximately two weeks before the show, the cast has been chosen and the script selected. The lighting director gets his script about a week before the show. About six days before the show, the cast gets together daytimes for rehearsals in a hotel ballroom, or some similar place out of the studio. They rehearse their lines and then, as time goes on, start to walk through their parts until the day before the show. In this dry rehearsal they're not only reciting the lines but are also performing the actions they will follow in the studio. There are no cameras. Tapes on the floor delineate where the scenery will be; and chairs are placed to denote furniture, doors and windows.

About 11:00 a.m. on the day before the show, the technical director of the show and the lighting director attend the dry rehearsal. When the lighting director comes to this rehearsal he receives two pieces of paper which help in lighting. One is the floor plan of the studio with the scenery shown in place. This is actually a scale print of the plan from which the scenery is set up. As he watches the dry rehearsal, the lighting director marks his floor plan, indicating actor's positions and actions. He also gets camera angles and microphone boom positions, which he marks on the plan. With this information he can start lighting the following morning.

The other piece of paper which the lighting director gets is called the *rundown*. The rundown shown in Fig. 5 happens to be for another show but is quite adequate to serve as an example. Notice that by telling the lighting director that Act One, Scene 1, is in the ranch house, pages 1–17 in the script, early morning, it gives him his mood and cues his lighting. Scene 3 is "twilight as scene begins, grows darker, dark by the time Starbuck enters." Here is an indication of the important use of dimmers to gradually change the scene during the show.

Although the lighting director has received the script a week or so ahead of time, and has read it, he knows that

SCENE & LIGHTING SEQUENCE

ACT ONE

SCENE 1	RANCH HOUSE	(1-17)	EARLY MORNING
SCENE 2	SHERIFF'S OFFICE	(17-24)	AFTERNOON
SCENE 3	RANCH HOUSE	(24-39)	TWILIGHT
			(AS SCENE BEGINS__GROWS DARKER__DARK BY THE TIME STARBUCK ENTERS)

Fig. 5. "Rundown" or scene sequence and lighting sheet.

in the control room he will not be able to use it. He can't follow a script while critically observing pictures on the control room monitors. Instead, he marks up his cues on the rundown sheet and goes by that. Then, he memorizes his cues for light changes, and depends on the notes in his rundown for any additional help he may need during the show.

The clutter of confusion in Fig. 6 is what the studio looks like at 9:00 a.m. on the day of the show. This is when the lighting director pauses to reflect on his way of life. His thoughts run something like this, "By air time tonight it's got to look good, because you're going on, and there are no retakes in this business." The scenery has been put up during the preceding night by a night setup crew. However, the dressing of the sets, such as adding the pictures, the drapes, and all the detail, is to be done during the day.

The lighting director has four electricians to work with for this show. One of the electricians goes up on the board to patch in the circuits and set up the switchboard. The fly man meanwhile operates the manila ropes and the counterweights to adjust the height of the pipes for that day's show. Another electrician starts hanging lights. The scoops or floodlights which supply the base or fill light, are in a ring around the front of each set. These go up first in all sets so that the actors and the cameras can see to rehearse.

The lighting director knows from his dry rehearsal of the day before what sets are going to be rehearsed in next, so he lights an idle set. When the actors get ready to move into that set he moves out to another set and comes back and finishes later, if necessary. This means a lot of movement; but the lighting is being done on the same day as the show, and not taking up a second day or night in the studio.

By 11:00 o'clock rehearsing with cameras starts. The actors are in and the show is fully rehearsing. From 12:30 until 2:15 is devoted to what is called *blocking the show*. The cameramen are told where to put their cameras for the shots, everybody takes time to lay out each shot, actors are positioned right, and then, later in the day, all the shots are put together and run through with continuity. From 2:15 to 3:15 the camera crew and the actors eat; and during this time the lighting director (he has eaten earlier with his crew) takes over and has the whole studio to himself and continues his lighting. From 3:15 to 5:30 blocking the show is continued.

During blocking and while he is lighting, the lighting director glances at the picture monitors on the studio

Fig. 6. Studio as lighting starts.

Fig. 7. One of sets in September 10 *Martin Kane* show, seen from above.

floor to get a rough idea of the completed lighting and camera shots.

From 5:30 to 6:30 there is a "break" in which the actors get notes. Lighting can meanwhile continue. From 6:30 to 7:30 p.m. there is a *run-through*. This is rehearsing the show against time, trying to get it all done with no stops. (There will, of course, be some stops; an hour is allowed for rehearsing a half-hour show). During this run-through the lighting director is up in the control room with the video operator and the technical director. The lighting director wears his headset with which he can direct the man on the dimmer board to adjust the dimmers for the right mood or the right light level. Also, other headsets can be plugged in on the studio floor so that he can talk to the electricians there. During run-through the lighting director sits in the control room and makes notes. He has no occasion to stop the cast or the actors to change lights.

There is another break from 7:30 to 8:30, during which the cast gets notes, and the lighting director goes down on the floor and makes any changes that he considers necessary. Dress rehearsal is from 8:30 to 9:00. This is almost as it is going to be on the air. The lighting director moves up to the control room during *dress*. Between 9 and 10 o'clock, just before air time, the lighting director is again on the floor, making any last-minute changes. Then 10 to 10:30 is air time.

One scene in the show, *Adelaide's Apartment*, is shown in Fig. 7. The view is down through the lighting pipes, and shows the lighting units and the pigtails into which they are plugged. This scene used approximately 25 lighting units, namely: eight scoops or floods, out front; ten 500-watt spots, six 1000-watt spots; and one 2000-watt spot. Figure 8 is a different view of the same scene showing the lights overhead. Notice the patterns of light and dark, plus depth creating shadows, on the walls. At the top of the picture are the scoops for the base lights. On two 1000-watt spots, barndoors have been used to create the dark uppers and light bottoms on the two doors. The bars on the window are projected through by means of a 2000-watt spot which puts the bars on the curtain, showing there is some light outside. The walls of the set are lighted with one set of lights and put on one dimmer. The actors are backlighted to make them stand out from the walls and the backlights are on another dimmer. The base, or the flat front-fill, light is on a third dimmer. The key lights to give the character and shadows to actors are on a fourth dimmer.

The lighting director, in the control room, can by talking to the switchboard electrician, immediately change the mood of the scene. He can bring up the flat base lights from the front, and flatten out the scene—or, he can reduce the base and vary the dimmers to give the type of picture that the program and technical directors want.

This show has nine major scenes and six minor scenes to light; yet lighting can be done in one day of studio time.

Discussion

Murray Dick (School of Radio Technique, Inc.): Have you completely done away with fluorescent lighting?

Mr. Ahern: Actually we have very little of it in use at the present time, for several reasons. The units are quite uncontrollable in beam spread, and also, a dimmer is only now being developed and it is rather complicated. Fluorescent lighting by itself seems to give a pretty harsh complexion—you have to have incandescent to get the proper tonal renditions that the director likes. By the time that is done you find yourself using quite a bit of incandescent. Also, with incandescent you have greater flexibility, for fluorescent lighting units are bulky and heavy to move around.

Mr. Dick: Isn't there a great deal of infrared light coming from your in-

Fig. 8. One of sets in September 10 *Martin Kane* show, showing lighting arrangement.

Fig. 9. Technical director, video operator and lighting director in control room.

candescents which requires to be balanced, maybe with the use of a Wratten filter?

Mr. Ahern: The combination of incandescent light and the color response of the image orthicon, you will find, gives scene color brightness response very closely matching the eye. For instance, the new image orthicons now are low in the red, counteracting the lights which are high in the red.

Henry Roger (*Rolab Studios*): Would it be possible to eliminate some of the human element during the actual performance by running a perforated strip of paper, such as actuates a player piano, a device which would automatically operate the lights?

Mr. Ahern: We have in use a couple of devices that approach that. The Center Theater has a very excellent switchboard of the preset type, with approximately 10 preset setups. Just by flipping one lever, you can bring up any one of 10 combinations. Also the Colonial Theater has the preset board on which, during the rehearsals, you set up your combinations. When the show goes on you press one button and lights come up in the intensities which were set.

John P. Muller (*WDSU Broadcasting Services, New Orleans*): Do you set any light levels with meters or mechanical means, or does your director just watch it on the monitor?

Mr. Ahern: All our lighting directors have light meters. Of course, with experience you get to the point where you can light pretty much by eye. You then use the meter as a check before going up in the control room and talking to the video operator. He may ask whether the light is too low and the lighting director can give him the measurement in foot candles. The video operator then knows whether he's got a camera tube that's giving trouble.

Mr. Muller: What type of meter is used?

Mr. Ahern: It's a special Weston, model 915.

Stereography and the Physiology of Vision

By EDWARD LEVONIAN

The transmission of an image from the original scene to the 3-D screen involves several transformations, the last of which occurs in the spectator himself. Analysis of any transmission system or theory has significance only as it pertains to the capabilities of the human visual apparatus. The spectator must be considered an integral part — the most important part — of the transmission system, and, as such, the evaluation of any system should be preceded by, and based on, a knowledge of the limitations imposed by the physiology of vision. It is the purpose of this paper to investigate some of these limitations.

It is possible to analyze mathematically the transformation of an object in the scene to an image on the screen. Yet to analyze in this manner the ocular, neural and psychological factors involved in perception not only is beyond the present state of knowledge but also presents problems in relating effects to a coordination of numbers. Therefore, consideration will be given only to a few physiological effects that are related to stereography, and no causal relationships in regard to these effects will be investigated.

In any transmission system using mechanically independent units, we must expect differences between the two aspects in registration, illumination, color, and in any other factor which is separately controlled for each aspect. To what extent such differences may exist without adversely affecting the intent of transmission is a problem which can be determined precisely only by experimentation, which, because of the large number of variables involved, is beyond the scope of this paper. However, since the body of knowledge in the field of physiological optics is more advanced than in the less explored field of film technology, it has been found economical to investigate certain evidences offered by the field of the physiology of vision which seem to have a bearing on the 3-D film. Such an investigation cannot replace experimentation in the theater, and, at best, can only lead to approximations which indicate the order and direction of mechano-optical accuracies which must

A contribution submitted September 24, 1953, by Edward Levonian, 1533 Fourth Ave., Los Angeles 19, Calif. This paper is an abridged portion of a thesis for an MA degree at the University of Southern California. Members of the thesis committee were William C. Blume, Chairman; Nicholas Rose; Paul A. White.

be respected in order for successful stereography to result.

The necessary relationship between the 3-D film and human vision is immediately apparent: the errors in transmission cannot be greater than the limitations imposed by the spectator's visual ability.

Steadiness of the Composite Image

The two aspects on the screen will usually vibrate with respect to each other. Such vibration is caused by a lack of film registration in cameras, printers and projectors, and by mechanical vibrations in apparatus. Under such conditions the fundamental frequency of the unsteadiness in each aspect is 24 cycles/sec.

In order to determine whether such unsteadiness can be adequately handled by the average spectator's visual abilities, it is necessary first to define such unsteadiness in terms related to physiological optics, and secondly, to determine the magnitude of the unsteadiness. This unsteadiness is adequately expressed in visual terms by the variation in the angle formed by straight lines passing through the right and left eyes and their respective point pairs on the screen. In the horizontal plane this angle is referred to as the convergence angle, while in the vertical plane it is known as the angle of vertical divergence.

As regards the magnitude of the intermittent variation in these angles, it has been determined that even in the extreme case of 16mm filming without registration pins, enlargement to 35mm, and projection on a standard 24-ft screen, the maximum intermittent variation in the convergence angle for a spectator seated 75 ft from the screen is about 6′ of arc, while the intermittent variation in vertical divergence is no more than 3.5′ of arc.[1]

Is this order of variation visually acceptable? Since the values cited will probably be the maximum encountered in the 3-D film, these values will be referred to the limitations of the visual apparatus, for, if it can be shown that these extreme values can be handled, it will be known that less demanding cases will certainly be acceptable.

First a determination should be made of whether such a variation creates the perception of a vibrating composite image. With the discriminating device (Polaroid glasses, for instance) removed, both aspects are seen by both eyes. Now the two aspects are seen to vibrate with respect to each other, for the visual Snellen acuity of the average spectator for normal motion-picture brightness is about one minute of arc, while the visual vernier acuity, which is more significant, is even less. With the application of the discriminating device can the spectator still detect movement in the composite image?

With the discriminating device inducing fusion, individual perception of either aspect is absent. Thus, the detection of unsteadiness can only be the detection of unsteadiness of the composite image. Conceivably this unsteadiness might be detected if, by fixation, each eye were to follow its respective vibratory aspect movement. However, the reaction time of the extraocular muscles is about one-tenth of a second,[2] so the eyes cannot possibly follow the 24-cycles/sec image movement due to a lack of film registration. Whether the reflex period is influenced by certain cerebral rhythms[3] or by the time delay at the synapses (junction points between the brain and the receptors in the retina) is not of particular importance for this discussion except that if it is the latter, there exists the indication that movements of points other than those fixated could be detected even less because of the added number of synapses for receptors outside the fovea.

Nevertheless, stereopsis exists even in the absence of willful innervation of the

extrinsic muscles,[2] so it cannot be assumed that unsteadiness cannot be detected simply because the eyes cannot follow the excitation frequency. Even when the spectator fixates a point, each eye undertakes independent excursions; the magnitude of such movements has a bearing on the steadiness of the composite image. Such movements are of two types: larger movements occurring at about 10 per sec,[2] and smaller twittering movements occurring at 50–100 per sec.[4] Only the former need concern us.

Since the larger excursions occur at the speed of 200–500′ of arc per sec,[5] the magnitude of each movement will be as great as 20–50′ of arc. These values have been substantiated by the independent method of Clark.[6] He found that when a spectator views a stereogram, each random binocular movement averages about 45′ of arc, each eye moving independently. The magnitude of this movement is independent of the fixation distance and of whether the fixation point is isolated or in context.

The precise amount the eyes vary during fixation need not be determined for our purposes. Suffice it to say that when the spectator is viewing a disparate picture presentation, each eye moves in a random and independent fashion. Since such eye movements are not sensed, it should be expected that relative movement between stimulus and receptor of an even higher frequency would not be sensed either. In the 3-D film such a relative movement occurs between one aspect and its respective eye, and hence, if detection of unsteadiness in the composite image is to occur, it must be due to some cause other than the frequency of the movement.

One such cause might be an excessive amplitude in the intermittent movement of either aspect. It appears that an image is fused and appears steady as long as it falls on a prescribed area of the retina about the fovea. It is often assumed incorrectly that in order for fusion to occur, an object which is imaged at one point in the retina of one eye must also be imaged at an anatomically corresponding point in the second eye. It is known, however, that as long as the object is projected on even noncorresponding points in the second eye, stereopsis will result as long as the noncorresponding points are confined to a restricted area. Such an area is called Panum's area. Thus, as long as the projection of the movement of a point on the screen falls within Panum's area, fusion should occur, and, for such a case, the composite image will appear steady because the mind cannot discriminate between retinal movement and aspect movement, for both types of movements are at a frequency higher than the willful eye movement frequency.

A knowledge of the angular extent of Panum's area is necessary in order to determine whether the intermittent variation of the convergence angle falls within this area. Charnwood gives the angular horizontal extent of Panum's area for the average spectator as 25′ of arc.[2] A similar value is given by Davson, who points out, however, that the ability to fuse point pairs falling on noncorresponding retinal points is influenced by the desire to see a single steady object, and this in turn is a function of the psychological condition of the spectator.[7] Thus it is seen that Panum's area may vary greatly not only among spectators but also in a single spectator at different times.

Other factors besides desire to fuse influence the size of Panum's area. Ellerbrook, using Polaroid filters to discriminate point pairs, separated such points in an experiment designed to determine at what point fusion disappears. He has found that the ability to fuse increases with an increase in the following factors: the period during which displacement takes place, peripheral fusional stimuli as against point sources at the fovea only, image size,

brightness, the degree to which one image is the same size as the other, and image definition.[8] The implication of these results to motion pictures is clear. The film composer has little control over the first two, but he can influence the spectator's ability to fuse point pairs by attention to the remaining factors.

Panum's area appears to have the form of an ellipse with the major axis being horizontal.[7] This would indicate a need for greater accuracy of film registration in the vertical direction than in the horizontal. The minor axis is only somewhat greater than the vertical intermittent movement of 3.5′ mentioned previously for the extreme case of 16mm filming with 35mm projection. However, the horizontal intermittent movement of 6′ of arc computed for the same problem is well within the major axis of Panum's area. Thus, for this transmission problem considered and for all general 3-D transmission, it is seen that the human visual apparatus is able to handle the errors in transmission due to a lack of film registration. However, simply because fusion will result and the composite image will appear steady, there is no guarantee that the spectator will not exhibit some other undesired effect, such as fatigue. Experimentation in the theater will best determine such possibilities.

Location of the Composite Image

The geometry of transmission allows the calculated image to be located theoretically anywhere in the theater space. However, there are limitations to the apparent location of the composite image, limitations which are psychological and physiological. Only the latter will be considered in this paper.

One physiological limitation on the location of the composite image is due to the fact that, in stereography, accommodation and convergence are separated, the former being relatively fixed for the screen distance and the latter varying as a function of the geometry of image presentation and viewing interest. The unnatural separation of accommodation and convergence could have two principal effects: (1) it could influence depth sense, and (2) it could restrict the location of the image. Does the separation of accommodation and convergence impose significant limitations on the placement of the composite image?

The influence of this separation on depth sense, or location sense of the composite image, has not been established for the 3-D film, so reliance is placed on more general information to indicate a probable answer, and even then no definitive theory exists.

For instance, the psychologist Gibson[9] feels that neither accommodation nor convergence can influence location sense because neither is a stimulus for depth perception. He states that both accommodation and convergence are results of more primary stimuli: accommodation, the reflex to the stimulus of blur at the fovea; convergence, the reflex to the stimulus of disparity; and that the image matrix on the retina, inasmuch as it is a function of distance by way of its gradient in size, texture, disparity and other depth cues, is a sufficient stimulus to depth perception. Gibson concludes that "present evidence makes it doubtful that they [accommodation and convergence] furnish any data for depth perception."[9]

This may well be true, but whether it is the gradients of blur and disparity on the retina or accommodation and convergence themselves which are the stimuli is a point of academic interest which need not be considered in the present discussion. In this paper the terms accommodation and convergence will continue to be used instead of blur and disparity without implying that the former terms are actually the factors which influence depth perception.

To dissociate accommodation and convergence in order to determine their

separate effect on depth perception presents problems in experimentation because of the reciprocal influence of one on the other.[6] To the extent that dissociation is possible, however, Swenson has found that the spectator senses the image at a point somewhere between the accommodation and convergence distances.[10] Generally the image appears about three-fourths of the way between the accommodation and convergence distances and closer to the latter. This result should not be directly applied to the peculiar conditions of stereography, but Swenson's results seem to indicate that, in the absence of other cues, convergence (or retinal disparity gradient) is a stronger cue to depth perception than is accommodation (or retinal blur gradient). However, the fact that the accommodation distance has some effect on depth perception might indicate that a transmission geometry which uses only the projection theory of vision to determine the calculated location of the composite image will result in a picture which is compressed toward the screen.

The comparative effects of accommodation and convergence on depth perception are of less importance than a comparison of the relative influence of either accommodation or convergence on depth perception as against that of other cues, cues such as binocular parallax, size of retinal image, interposition, aerial perspective, linear perspective, detail perspective, motion parallax, brightness, and light and shadow. The first one is a binocular cue, the remainder monocular. When binocular cues are in conflict with monocular, it is generally the latter which influence the determination of depth, particularly for distant images. For instance, the cue of interposition, or overlapping, is stronger than stereopsis.[12] The reason for the superiority of monocular cues may lie in the fact that binocular vision requires some outside factor to give it scale,[13] and this outside factor is usually one or more monocular cues.[2] All the monocular cues, with the exception of motion parallax, are present in 2-D and 3-D motion pictures. Therefore, it is concluded that accommodation at the screen or convergence at the image has relatively little influence on the depth perception of the composite image.

In regard to the second possible effect of the separation of accommodation and convergence, namely the effect of restricting the location of the image, it is known that this separation or dissociation is not unlimited. Furthermore, it is not necessarily constant for any one spectator, being a function partly of the psychological condition of the spectator.[11] For the average case in the clinic, the ability to diverge the eyes is about three prism diopters (about 1.5°), while adduction, the ability to converge the eyes, is about nine diopters (about 5°) for each eye. Since in normal stereography the spectator's eyes are accommodated essentially for optical infinity, the spectator is theoretically able to diverge from infinity to minus 7 ft and to converge on a point only $1\frac{1}{2}$ ft in front of his eyes. The dissociation of accommodation and convergence seems theoretically not to restrict the location of the image in the theater.

However, comfortable viewing is impossible unless the extreme planes are kept within certain limits, and Duke-Elder states that as a good general rule people are able to exercise only the middle third of their relative convergence without visual fatigue.[11] The approximate application of this rule to motion pictures means that visual comfort is maintained as long as the geometrical location of the image is restricted to the region from 5 ft in front of the spectator to infinity. The restricting case for all spectators is, of course, determined by the distance from the screen to the closest spectator.

Duke-Elder's rule would indicate a maximum separation of point pairs equal

to the human interocular. However, it is emphasized that the rule just given for the limitation of the image in the theater is only approximate, and research is needed to determine the extent, in both magnitude and period, to which infraction of this rule is possible for the unique conditions of the 3-D film. Experimentation should be undertaken in the theater, not the clinic, so that usual motion-picture conditions apply. It may well be that for such conditions some divergence can be tolerated with comfort, particularly if the nearest plane is not as close to the spectator as has been shown possible. Such a possibility has its advantages in the mechanics of filming.[17]

Vertical Disparity of Point Pairs

So far only intermittent movements of point pairs have been considered. However, mechanical, optical and human errors in transmission will also result in steady errors in the placement of point pairs. Such steady errors will usually last for at least the duration of the shot. The effect of steady errors in the distance between point pairs in the horizontal direction is to create an error in the intended location of the composite image. The extent of this error in location is a function, partly, of the psychological condition of the spectator,[1] and hence will not be considered in this paper. The effect of steady errors in the distance between point pairs in the vertical direction is to create a condition forcing one eye to be angled upward. This unnatural act may cause either fatigue or diplopia, depending on its magnitude.

The extent to which one point of a point pair can be elevated without causing diplopia will now be investigated. Ellerbrook separated point pairs in the vertical direction in order to find out at what separation diplopia first occurs.[8] He found that fusion still maintains as long as the amplitude of vertical divergence is not much greater than 1°, a value corroborated by Davson.[7]

Again, for the same extreme case of 16mm filming with 35mm projection in a regular theater, it has been computed that the addition of all normal mechanical, optical and human errors cannot cause a vertical divergence greater than 14′ of arc for a spectator seated 75 ft from the screen.[1] This maximum value is for point pairs located at the top or bottom of the screen; vertical disparity between point pairs at the center of the screen will be considerably less. Even for the closest spectator to the screen, the vertical divergence induced by a vertical disparity in point pairs is much below that necessary to cause diplopia.

It has already been mentioned that Ellerbrook found that the ability to fuse vertically disparate point pairs increases as the fusional stimuli approach the periphery of the visual field.[8] It is fortunate that a greater amplitude of vertical divergence is possible for peripheral stimuli, because vertical disparity of point pairs increases at the corners of the screen due to the convergences of cameras and projectors (keystoning).

Disparity in Magnification

It can be shown that the convention of always keeping longer lenses on the same side, say the left, in both filming and projecting would help minimize the effect of the disparity in the magnification of the two aspects due to a disparity in lens focal lengths.[1] Nevertheless, such a disparity in magnification may exist, and, as can be shown, may cause an error in the apparent location of the composite image, particularly at the side borders where horizontal disparity is most evident.[1] Magnification disparity may also cause headache, fatigue or diplopia, particularly for images near the top and bottom borders where vertical disparity is most pronounced.

Still another aberration may be caused

by a difference in magnification between right and left aspects. If one image is magnified in the horizontal direction more than the other, the subjective orientation of the composite image will be rotated about a vertical axis which passes through the point of fixation.[14] In such a case, Panum's area has the effect of rotating about its minor axis, decreasing the region where single vision is possible. It appears, therefore, that when magnification disparity exists, film registration should be more exact.

More recent work by Ogle shows that if the magnification disparity is only in the vertical direction, a similar subjective orientation rotation takes place, but in the opposite direction to that caused by horizontal magnification disparity.[15] Thus, as long as the lenses are astigmatically corrected, subjective rotations are cancelled out. However, the magnification disparity, albeit anastigmatic, has limitations outside of which cancellation of image rotation is ineffective. This limitation is given by Ogle as a 5% difference in magnification.[15] This value, according to Ellerbrook, is the same difference in magnification above which fusion no longer obtains.[8]

Such a large magnification disparity, however, does not normally occur, so it is concluded that the principal effects of a disparity in magnification between the two aspects are errors in apparent location, the necessity for vertical divergence of the eyes, and effects due to aniseikonia.

Disparity in Brightness

The use of separate films in stereography may result in a disparity of aspect brightness due principally to differences in film densities and in projection illuminants. The tolerance of such a disparity can be determined precisely only by actual tests. However, certain physiological effects of brightness disparity are known and are certainly indicative of the problems involved.

The eye is capable of discriminating brightness differences of only 1%,[12] but does this value set the limitation within which brightness disparity must be restricted? Murroughs[12] implies that brightness disparity should respect this limitation, yet Sir Charles Sherrington[2] has found that the light to one eye may be reduced 96% before binocular vision disappears. The problem of brightness disparity is not simply a restriction to thresholds, but is rather a determination of acceptable brightness differences between the two aspects. Such a problem can be resolved only by experimentation under normal 3-D projection conditions. Should one aspect become grossly more bright than the other, ocular dominance in favor of the brighter aspect will occur, whereas, as Davson points out,[7] a lesser disparity may instigate the appearance of luster. Tests will determine these thresholds.

A disparity in screen brightness will also have the effect of creating a disparity in the acuity of each eye, for it is known that, within the linear portion of the photopic illumination – visual acuity curve, effective for normal motion-picture viewing,

$$\text{Acuity} = K \log (\text{illumination}).^{16}$$

This difference in acuity between the two eyes due to a disparity in aspect brightness may be heightened by the present tendency to use aprons around the screen to yield a surround brightness. Since maximum acuity is achieved if the surround brightness is equal to the image brightness,[11] then, if the apron is made of some non-depolarizing material such as that used for the screen, the disparity in acuity will be due not only to a disparity in illumination but also to a disparity in the brightness of the surround.

An intentional disparity in brightness is one method, although not recommended, of increasing the subjective

brightness of the composite image due to the effect that, as Sherrington[2] has investigated, the subjective summative effect of illuminations unequal in magnitude to each eye is somewhat higher than the mean of the two uniocular brightnesses. However, a better method of solving the acute problem of a decreased brightness in the 3-D film may lie in the use of optically active materials for polarizing the projected light. Such materials (e.g., quartz, Rochelle salt, camphor, turpentine, etc.) may effect a utilization of rejected polarized light. Research on this possibility should take into account the use of illuminants with spectral qualities different from those in present use. The employment of illuminants composed of two or more narrow wavelength bands may prove profitable as long as the additive effect of such bands yields an acceptable illuminant as regards color, while the locations of such bands in the spectrum are such that all or some of them can be rotated into the transmitted plane while any rejected light is normal to this plane. The choice of wavelengths should also consider the fact that acuity is a function of wavelength and that this function varies according to whether the illumination level is scotopic or photopic.[16]

Disparity in Color

The use of two separate films may lead to a disparity in color due to differences in filming, processing or projecting. The effect of such a disparity on perception is a function of differences in both wavelength and luminosity. Davson[7] gives the following three rules: (1) where colors are somewhat different and luminosity is essentially the same, color mixing is possible and conforms to the laws of monocular color mixing; (2) where colors are grossly different and luminosity is the same, color replacement occurs in which first one color, then the other, is perceived; (3) where colors are grossly different and luminosity is also different, ocular dominance occurs in favor of the longer wavelength and brighter aspect, but where these two factors are incompatible, that aspect effecting the stronger sensation will dominate.

In general, the right and left aspects will not differ greatly in either hue or brightness, and thus a mixing of both factors would be expected rather than replacement or dominance. However, the extent to which color disparity may exist without causing undesirable effects on the spectator must be determined specifically for 3-D conditions.

Differences in colors between the two aspects may also cause the light from one point in the field to be refracted differently than the light from its point pair due to the fact that the indices of refraction of the various fluids in the eye are functions of the wavelengths of the t.ansmitted light. This chromatic aberration exists even if right and left aspects are identical. In the case of color disparity in the two aspects, no adverse effects due to ocular chromatic aberration are predicted as long as the disparity is not excessive, for in this case the image will fall within Panum's area.

Only a few of the factors of stereography have been related to the physiology of vision. No investigation has been made of the effect on the spectator of such considerations as the alternate presentation method of 3-D motion pictures, the anaglyph method, the transmission of a portion of the left aspect to the right eye, a disparity in the shutter phase angle wherever shutters are employed in the transmission system, binocular flicker frequency as against monocular, the reduction of depth perception due to reduction of light by the discriminating devices, the orthoptics of stereography, and other factors. For such considerations, and those that have been investigated, much experimental work must be done with specific motion-picture applications in mind.

DEFINITIONS OF MAJOR TERMS

Aspect: Either right or left view taken as a whole. Also known as a field.

Composite image: The resultant sensation experienced by a spectator by the proper viewing of disparate images.

Diplopia: The conscious sensation of seeing a single object as double.

Discriminating device: Any contrivance which allows each aspect to reach only the eye for which it is intended.

Disparate images: Two slightly different views of the same subject, one view being intended only for the left eye, the other only for the right.

Fixate: To direct one's eyes upon a point.

Point pairs: Right and left image points on the screen which, when fused by the spectator, appear as a single point in space.

Snellen acuity: A measure of the spectator's ability to see the separation between two points close together.

Stereography: The application of stereoscopy to photography.

Stereopsis: Perception of depth by the fusion of disparate images.

Stereoscopic cinematography: Motion-picture photography which allows the spectator to perceive depth.

Vernier acuity: A measure of the spectator's ability to see the offset from a line of a portion of that line.

Vertical divergence: The vertical angle between the optic paths to each eye.

Visual perception: The mental result of the influence of the psychological condition of the spectator upon a visual sensation.

Visual sensation: A primitive mental reaction to a stimulation of the retina by light waves.

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Auxiliary Multitrack Magnetic Sound Reproducer

By C. C. DAVIS and H. A. MANLEY

A four-track magnetic soundhead for reproducing CinemaScope films in theaters is described. The unit mounts readily between projector and upper film magazine and is film driven. To facilitate threading, the film sprocket is locked when the pressure pads are opened. A low natural-period Davis filtered drive insures high-quality film motion.

When Twentieth Century-Fox began the CinemaScope program, the Westrex Corporation was requested to design a special multichannel magnetic soundhead which would reproduce the four striped magnetic tracks on the composite release print employed in the CinemaScope presentation. The general requirements called for a unit, not to exceed 5 in. in height, to be mounted between the top of the picture projector and the upper magazine, capable of being installed with a minimum of effort. A 28-frame separation between picture and sound start marks was specified and provision was to be made in the soundhead for adjusting the length of the film path to accommodate different projectors employing varying film path lengths.

The CinemaScope program appears to be the first to utilize commercially a composite multitrack sound and picture release print. Figure 1 illustrates such a print and shows the location and dimensions of the four tracks. Tracks 1, 2 and 3 provide the three-channel stereophonic sound, while the fourth track is for special sound effects to be reproduced in the auditorium. It will be noted that the sprocket holes have been reduced in both width and height. The reduction in the width of the holes makes additional space across the film available for the multiple sound tracks.

The Westrex Stereophonic Reproducer has been designed to reproduce the four tracks of a CinemaScope release print without materially affecting the normal operation of theater equipment with standard release prints. For operation with standard release prints the equipment in the auxiliary head is by-passed and the film is threaded over two rollers and into the projector.

In considering the design of a film-pulling mechanism to meet the requirements, past experience indicated that three factors required special consideration. The first of these factors was obviously the successful scanning of the relatively small magnetic tracks adjacent to the sprocket holes. The solution was found to be an optimum combination

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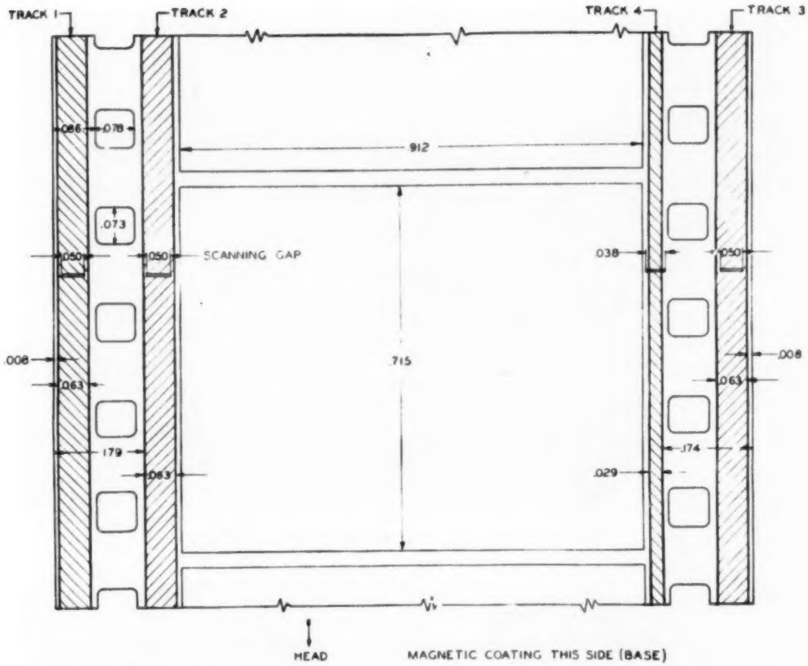

Fig. 1. Proposed sound-track standards for CinemaScope.

of film tension and angle of wrap about the heads which produced good head contact without excessive polygoning of the film, which occurs in increasing amounts in the area adjacent to the sprocket holes as the angle of bend of the film is increased.[1]

The second factor called for the design of a mechanical filter mechanism with an exceedingly low natural period in order to discriminate against as many as possible of the external disturbances which may arise in the projector mechanism or in the upper magazine. This in turn required an especially wide working range of the filter arms to avoid the possibility of their engaging their stops, due either to maladjustment or changes in coefficient of friction of the film coatings against the magnetic head.

The third factor arose from the small diameter of the impedance drums and bearings due to space limitations, and placed a severe requirement on the concentricity of these parts to avoid proportionately increased flutter at a 5.7-cycle rate to which the ear is quite sensitive. This condition was minimized by making each drum and shaft from a single piece of stainless steel and employing a precision-ground finish.

The reproducer is shown in front view in Fig. 2 and Fig. 3 is a rear view with the cover removed. The unit is readily installed by removing the upper magazine and fire trap, mounting the reproducer on the picture projector and mounting the magazine and fire trap on the reproducer. Figure 4 shows the unit mounted between the upper magazine and the picture projector. The

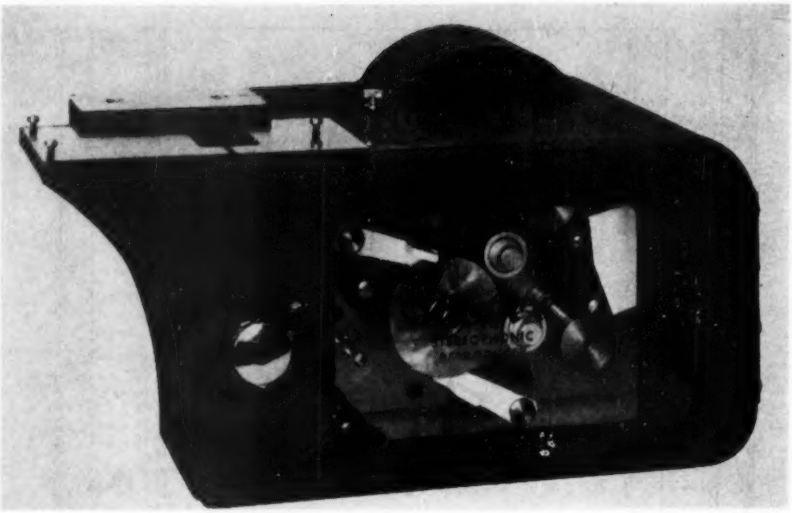

Fig. 2. Front view of reproducer.

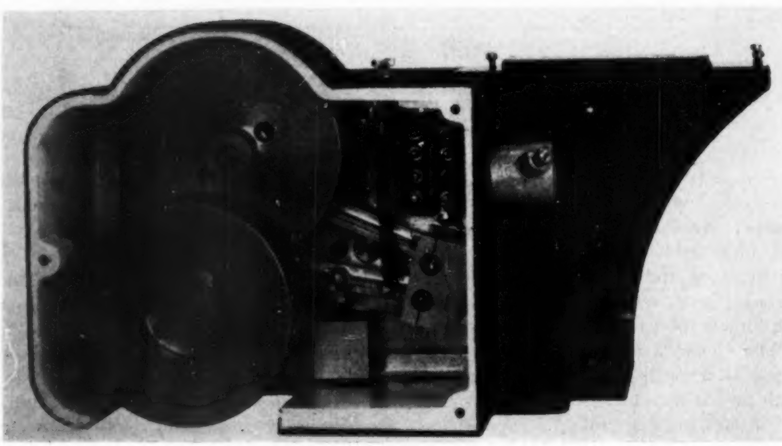

Fig. 3. Rear view of reproducer with cover removed.

upper magazine is mounted toward the left of the unit to provide a minimum of interference between it and the booth wall where steep angles of projection are encountered.

The reproducer consists of a cast housing provided with a front hinged door and a rear cover, and contains a film-motion filtering system and associated guide rollers, a four-track magnetic head and a terminal strip. The mechanical items are assembled on a base plate and can be taken out as a unit by first removing the two flywheels

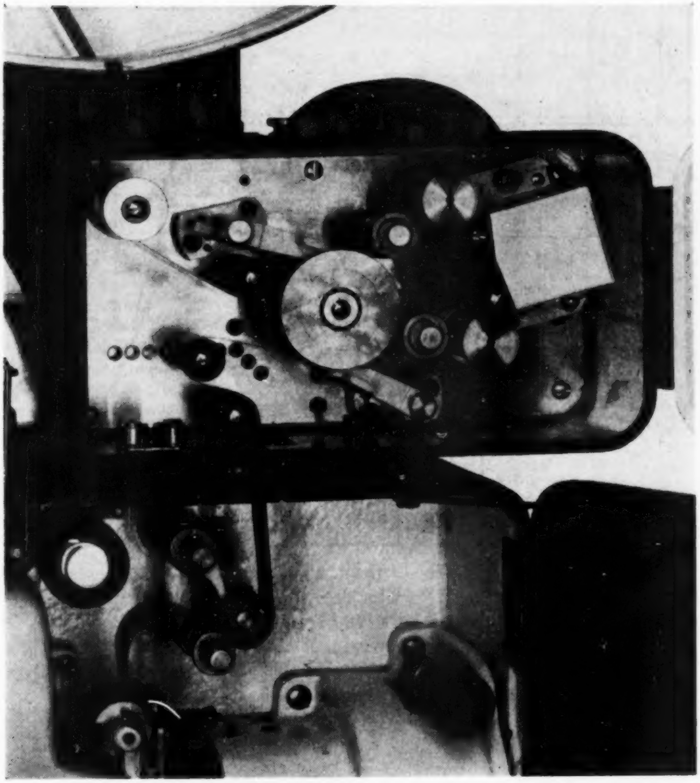

Fig. 4. Reproducer mounted between projector and upper magazine.

and unhooking a spring, and then releasing four corner mountings.

Figure 5 is a schematic representation of the base-plate assembly. It shows the path of CinemaScope film through the filter mechanism, over the magnetic head and around the idler rollers. It will be noted that the mechanism is similar to other magnetic film-pulling mechanisms using the Davis drive[2] with two impedance drums, except that in this instance the dual-purpose large sprocket is film driven, the film being driven by the upper film sprocket in the picture projector. Since the length of film path from the picture aperture to the top of the housing varies in different makes of projectors, one idler-roller position has been made adjustable and is set at the time of installation to compensate for this variable and to provide the correct separation of 28 frames between picture and sound.

The filter-arm assembly is similar to those used on previously designed machines except that in this case the filter rollers are without flanges, the film being guided by flanges on the film sprocket. Threading is aided by holes through two targets on the filter arms which become concentric when the correct length of film is threaded. The

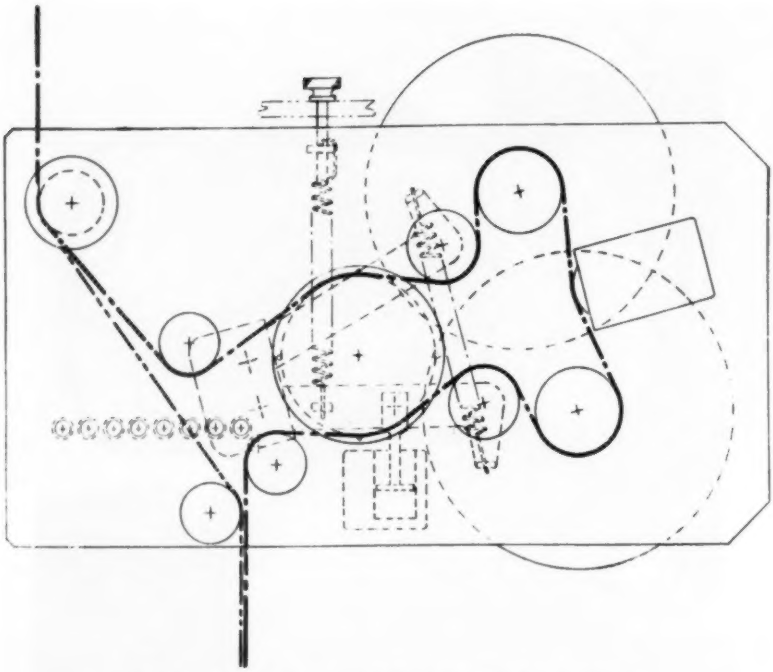

Fig. 5. Schematic representation of base-plate assembly.

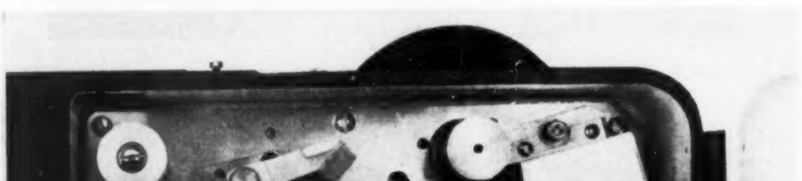

Fig. 6. View of reproducer showing method of locking sprocket.

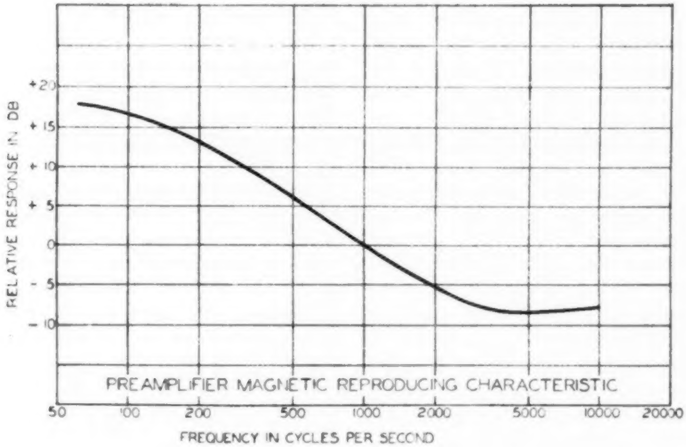

Fig. 7. Frequency characteristic of preamplifier.

front surface of the rear target is painted red, adjacent to the target, so that the red shows through the hole when an incorrect length of film is threaded. The filter arms are capable of an unusually long excursion to provide a wider range of operation of the filter system.

Two similar pad arms prevent the film from running off the sprocket. If the sprocket were always free to rotate, it would present a somewhat awkward situation during film threading. However, means have been provided for locking the sprocket when either pad arm is open. The method by which this is accomplished may be seen by reference to Fig. 6 which shows the reproducer with the sprocket removed. The inside face of the sprocket contains a gear with internal teeth, and two pawls are mounted within the sprocket-shaft assembly which is fixed in position. A common spring forces the pawls radially outward so that they engage the teeth of the internal gear and lock the sprocket at two points. An extension on each pad arm depresses one pawl and disengages it from the gear teeth when the pad arm is closed. Therefore, when both pad arms are closed at the completion of film threading, the sprocket is free to be driven by the film. The angle of engagement of the pawls has been selected so that while they hold the sprocket sufficiently rigid for threading, they will slip at a tension considerably below the breaking point of the film. This insures against a film breakage should the operator fail to close the pad arms before starting the motor. All film-contacting surfaces have been undercut in the picture area to avoid possible abrasion of either film base or emulsion surface. The rotating elements in the filter system are ball-bearing mounted, except the sprocket which has a specially lubricated Oilite bearing. The three idler rollers are made of graphite-impregnated nylon and require no lubrication. The guide roller in the upper lefthand corner has an Oilite bearing. This results in a mechanism that requires no lubrication.

The magnetic-head assembly consists of three 50-mil heads and one 38-mil head located on a common axis and mounted on a base plate. The spacing of the head scanning centerlines is fixed at the time of assembly in ac-

cordance with the CinemaScope proposed standards for magnetic sound reproducing equipment. The heads are shielded against stray magnetic fields by a mu-metal case and shield. The heads contact the film at a point midway between the two drums, thus maintaining a symmetrical relationship of film wrap about the gap regardless of variations in film compliance. Means are provided for adjusting the heads as a unit to insure correct azimuth, centering of the gap and track position.

An amplifier assembly, consisting of four preamplifiers mounted in a metal box, has been designed to provide a signal output from the four magnetic heads at a nominal level of −12 dbm for the stereophonic tracks and −18 dbm for the effects track. The frequency response characteristic of the amplifiers is shown in Fig. 7. This characteristic, together with that resulting from scanning with heads having 0.5-mil gaps, gives an overall reproducing characteristic which is in accordance with the standard proposed by the Motion Picture Research Council. The resulting overall frequency characteristic is flat from 50 to 8000 cycles/sec. within the limits of the proposed standard.

The auxiliary soundhead described in this paper offers a simple and relatively inexpensive means of reproducing CinemaScope stereophonic sound films with a high degree of fidelity. When mounted on a projector in good operating condition, low-frequency flutter components are not greater than 0.03%, while the total root-mean-square value of flutter is within the 0.15% value which is the generally accepted requirement for theater equipment. The guiding of the film at the sprocket reduces film weave to a minimum which is particularly desirable with the use of narrow tracks. Maintenance requirements have been reduced to a minimum. There is no contact with the film in the picture area, no lubrication is required, the mechanism stabilizes well within the allotted starting time and complete facilities are provided for alignment should occasion arise for the ultimate replacement of the magnetic head.

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Film-Pulled, Theater-Type, Magnetic Sound Reproducer for Use With Multitrack Films

By J. D. PHYFE and C. E. HITTLE

This paper describes a new type of sound reproducer which attaches to the top of standard 35mm theater motion-picture projectors. The unit permits elective playing of conventional photographic sound films by means of the usual projector-soundhead combination or magnetic tracks by means of the attachment. Sound reproduction using the attachment is of excellent quality and falls within Research Council recommendations for magnetic-track reproduction.

Methods of motion-picture presentation have undergone some drastic changes since the more or less static period of the thirties and forties. Now the public may choose their type of theater entertainment from among several including the old 2-D, the new 3-D, and the enlarged-screen types. The new types have one feature in common, the use of multiple sound channels entailing the use of film having a multiplicity of soundtracks. Most of the new film systems are using separate magnetic soundtrack type of films for the sound system. A system recently developed by Twentieth Century-Fox Film Studios, however, is a single-film type including both picture and multiple soundtracks on one 35mm film. In this film system, multiple stripes of magnetic coating are applied to the picture film after processing, and then the individual soundtracks are recorded on the magnetic striping with the sound lagging the picture by 28 frames. The magnetic stripes are located as shown in Fig. 1 with the striping applied to the base side of the film.

A new type of magnetic sound reproducer is required to reproduce the sound of such composite picture-multi-soundtrack film. Since the sound lags the picture by 28 frames, the reproducer must be mounted on top of the projector to satisfy the picture-to-sound displacement requirements.

A sound reproducer designed specifically for the new composite-type film is shown mounted on a projector in Fig. 2. Available mounting space on the top of the various makes and models of projectors currently in use in theaters influenced to some extent the size and shape of the unit. Compactness of the

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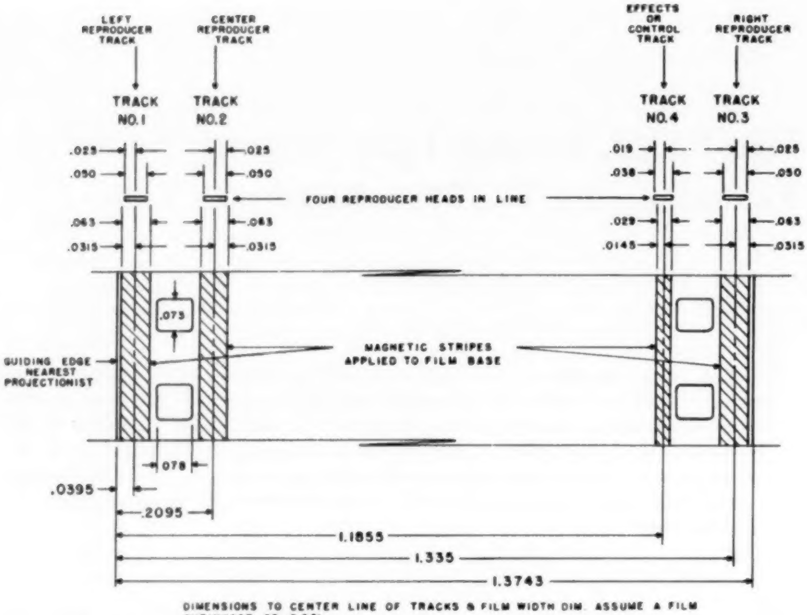


Fig. 1. Proposed magnetic-track standards for CinemaScope-type film.

Fig. 2. Magnetic soundhead mounted on RCA projector.

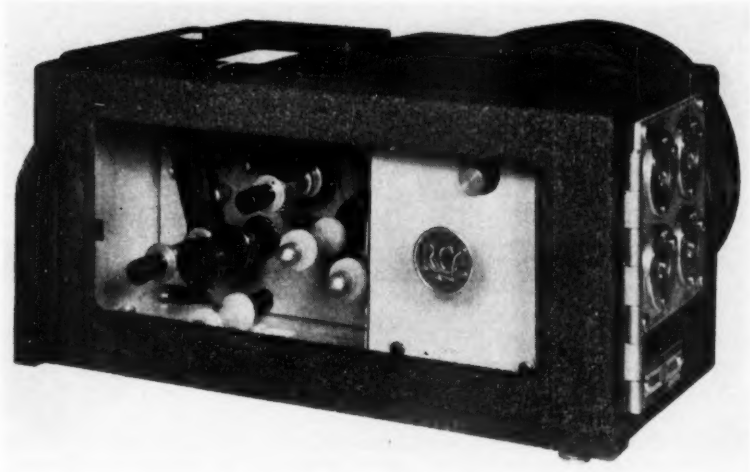


Fig. 3. Magnetic soundhead.

reproducer and simplification of the mechanism was made possible through a unique operational feature. The film is pulled through the unit by the picture projector, thus eliminating the need for a separate interlock drive motor or drive gearing from the projector.

Some idea of the compactness of the unit may be obtained from Fig. 3. In this view may be seen the door, mechanism housing, rear cover and part of the mechanism-panel assembly visible through the glass window of the door. The first three parts mentioned above plus the mechanism panel are of cast aluminum construction. The exterior of the unit is finished in an umber gray wrinkle. A light-colored finish is used on the inside surfaces to provide better visibility for threading.

The door is hinged and is attached to the housing at the right side in accordance with standard projector and soundhead procedure. The rear cover is attached by screws since it seldom need be removed. The mechanism-panel assembly is supported in the housing by means of four rubber isolation mounts with adequate clearance being provided between the edges of the panel and the interior of the housing to eliminate any metal-to-metal contact between the panel and housing. Likewise, no parts affixed to the panel, other than the isolation mounts, are in contact with any parts fastened to the housing. This is an important feature of the design since experience has proven that vibration of the magnitude, which may be present with the majority of motion-picture projectors, can adversely affect the film motion at the region of film contact with the magnetic head, giving rise to excessive high-frequency flutter.

Figure 4 shows the soundhead with the door open. Mounted on the mechanism panel may be seen the upper and lower film sprockets, pad rollers, sprung-flange guide roller, pressure roller, impedance drum, magnetic-head assembly, a sprung double-roller assembly, three fixed-position rollers, which assist in formation of the correct film path through the unit, and part of the shield of high-permeability metal

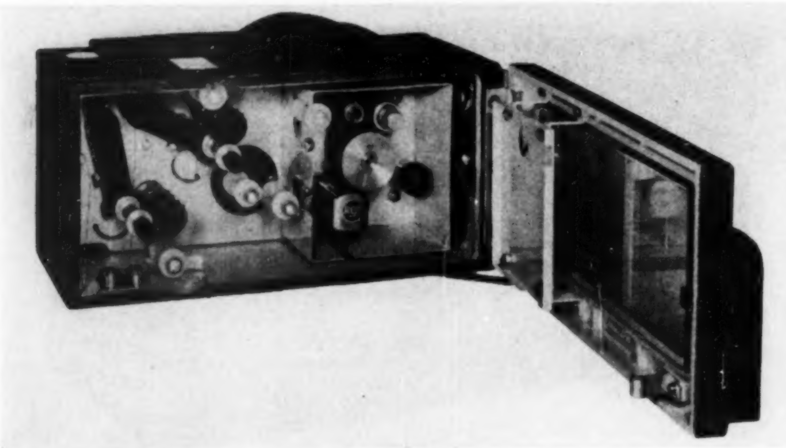


Fig. 4. Magnetic soundhead, door open.

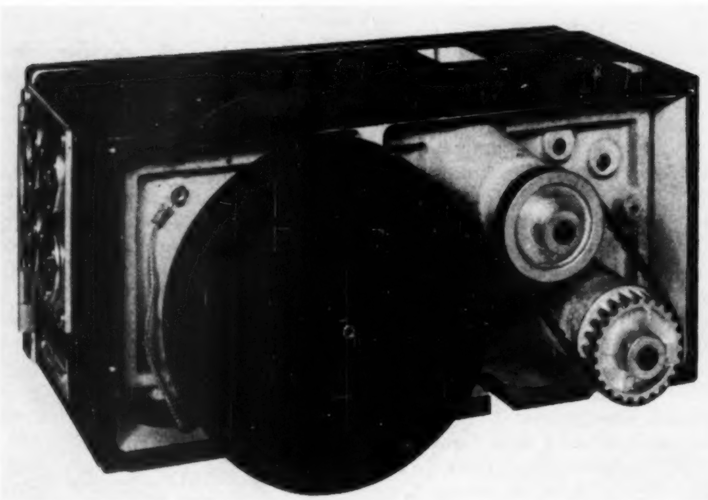


Fig. 5. Magnetic soundhead, rear cover removed.

which encloses the area in which the magnetic head is located. (The front cover of the shield is attached to the rear face of the door to facilitate access for film threading.) The two sprockets and associated rollers are offset vertically with respect to each other, to permit film threading downward from the feed magazine to the projector, by-passing the magnetic-head section of the soundhead, when using standard photographic soundtrack type of picture film. If

film guiding through the soundhead is desired, the film may be threaded around the sprockets and pad rollers only.

The upper sprocket is driven from the lower sprocket by means of timing-belt type of pulleys mounted on the rear of the sprocket shafts and a connecting precision-molded, tooth-type rubber belt shown in Fig. 5. This drive gives results comparable to a precision gear drive at considerably less cost. During operation with the film threaded for magnetic sound reproduction, as the film is pulled into the projector by the projector feed sprocket, the downward film pull causes the lower sprocket of the magnetic soundhead to rotate. The upper or feed sprocket is driven at the same speed as the lower sprocket since the belt drive is as positive as a gear drive and the pulley ratio is one to one. Both sprockets are of the 16-tooth type with tooth width and tooth pitch selected specifically for the new composite-type film and the new functional usage of the sprockets. The primary reason for incorporating two 16-tooth sprockets in the design rather than one 32-tooth sprocket is directly related to the type of filter system used and the desirability of keeping the height of the soundhead to a minimum consistent with good design practice. Use of the two sprockets simplifies film threading since a natural film wrap is afforded about the sprockets for the desired film path.

The filter system is a film-pulled, drum-type, soft-loop system. Drum-shaft assembly includes a solid flywheel mounted on the rear of the drum shaft. The flywheel is protected from accidental contact by operating personnel during operation of the unit by the rear cover of the soundhead. The double-roller assembly mounted between the magnetic-head assembly and lower sprocket comprises a second portion of the filter system. The two rollers are mounted on a common arm which in turn is mounted to a pivot shaft at a point midway between the two roller shafts. The assembly is biased by means of a clock-type spring enclosed in a cavity at the rear of the pivot-shaft housing. Damping is afforded by use of silicone grease in the spring enclosure and shaft bearing. The primary soft or compliance film loop is formed between the feed sprocket and drum. (Had a single 32-tooth sprocket been used, additional height would have been necessary to provide clearance between the soft loop and the film passing around the rollers of the double-roller assembly.) Most of the random irregularities in film motion on the feed side of the soundhead are absorbed in the compliance loop ahead of the drum.

Tests were made on models of both tight-loop and soft-loop filter systems. Film motion was comparable on the two systems when used with a projector having good feed-sprocket motion and a feed magazine producing uniform drag or holdback. However, when projector feed-sprocket motion and feed-magazine drag were not uniform, a condition likely to be encountered in the field, film motion obtained with the soft-loop filter system was superior to that obtained with the tight-loop system.

An improved method of construction for multiple heads* has been incorporated in the design of the magnetic-head assembly shown in Fig. 6. The four heads are contained within a single, precision-cast housing. The face of each half cluster is lapped on a precision flat which inherently makes all the gaps in true alignment when the half clusters are assembled together. The azimuth, head height and track location are accurately adjusted with respect to the mounting surface during assembly. After all assembly and final lapping operations are completed, the

* Kurt Singer and Michael Rettinger, "Multiple-track magnetic heads," *Jour. SMPTE, 61:* 390–394, Sept. 1953.

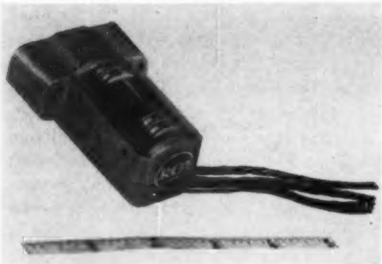


Fig. 6. RCA 4-track magnetic-head assembly.

heads are inspected for conformity to design specifications for azimuth, head position, inductance and uniformity of output.

The head assembly is mounted in the soundhead adjacent to the drum so that the film contacts the head immediately after leaving the drum. Angle of contact of film on head is approximately thirty degrees. This degree of contact assures minimum amplitude modulation and is beneficial in prolonging useful head life. The head location is at the portion of the film path where best film motion exists.

Flutter content is less than 0.15% rms when measured with a test film having a flutter content of less than 0.1% rms. Amplitude modulation is less than 1 db. Uniformity of output is within $1\frac{1}{2}$ db at 8000 cycles and 1 db at 1000 cycles.

Since the size and configuration of the top surface of various projectors currently in use vary, it was impractical to design the soundhead for universal mounting. Instead, the unit was designed for mounting on a projector having a flat top surface of adequate area, and adapters have been designed and will be available to permit mounting the soundhead on the various other projectors now in use.

This magnetic reproducer will permit the same projector soundhead now reproducing optical tracks to reproduce multichannel or stereophonic sound without the need of a separate interlocked magnetic dummy. By combining the ability to reproduce either photographic or magnetic soundtracks into one projector-reproducer assembly, considerable savings may be realized over the double-film systems. Also, no additional floor space is required in the theater projection rooms. Sound reproduction using the attachment is of excellent quality and is within Research Council recommendations for magnetic-track reproduction.

Four-Track Magnetic Theater Sound Reproducer for Composite Films

By S. W. ATHEY, WILLY BORBERG and R. A. WHITE

A four-track, magnetic sound reproducer which mounts between the upper magazine and the picture mechanism of a standard theater projector is described. Features include: minimum increase in overall projector height, no interference with normal projector operation and excellent film motion. The use of this unit for the initial experimental recording work which produced the first composite CinemaScope film demonstrations is also described.

In the early part of 1953, the Twentieth Century-Fox Film Corp. demonstrated the wide-screen motion-picture process now known as CinemaScope to motion-picture industry groups, and asked the equipment suppliers of the industry to attempt the development of methods for carrying a stereophonic sound record on the same release film with the picture.

In response to this request the equipment described here was developed in two overlapping stages: (1) the development of a practical method of recording and reproducing stereophonic sound on a single 35mm film, which would at the same time leave the maximum amount of space available for the CinemaScope picture; and (2) the commercial development of theater equipment for reproducing such a stereophonic sound record.

Twentieth Century-Fox originally proposed that sound be carried on three 50-mil magnetic stripes applied adjacent to the sprocket holes of standard 35mm film. This proposal was modified in many ways during the months that followed, but eventually became the basis of the final commercial-release version of CinemaScope film. The sprocket holes were narrowed, and the space made available by this change was used to add a fourth "effects" or "audience surround" track and to widen the three main tracks to 63 mils; otherwise the original proposal was retained. The final release-print standards were established by Twentieth Century-Fox on the basis of information and reports of progress transmitted to them by this company and others working simultaneously on the same problem. A drawing of the release-print picture and sound-track locations

Presented on October 6, 1953, at the Society's Convention at New York by S. W. Athey (who read the paper), Willy Borberg and R. A. White, General Precision Laboratory Inc., Pleasantville, N.Y. (This paper was received Jan. 12, 1954.)

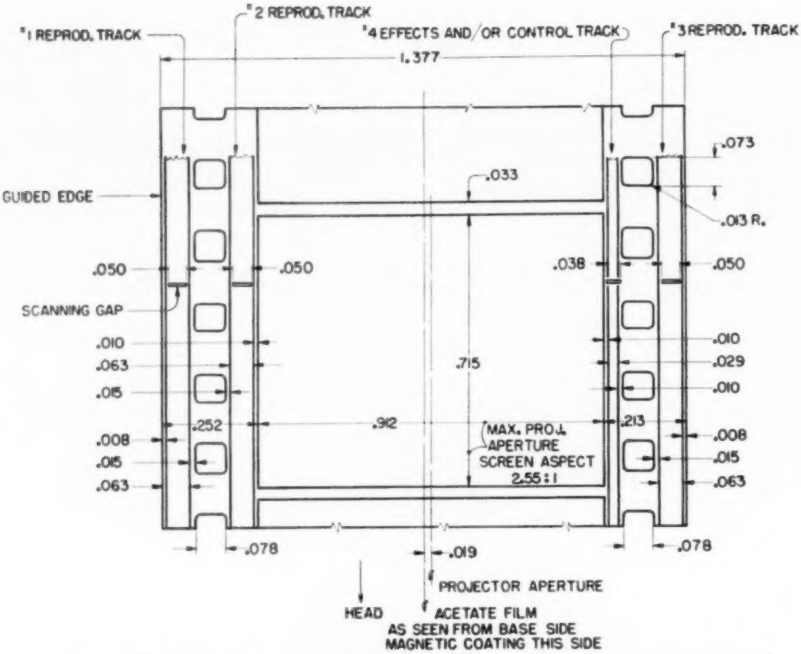


Fig. 1. Proposed release-print standards for CinemaScope sound track and projector aperture.

as presently used by Twentieth Century-Fox is shown in Fig. 1.

General Precision Laboratory Inc., made the first single-film stereophonic recordings of Twentieth Century-Fox demonstration material with a production prototype of the soundhead described below four months after the presentation of the problem. Electronic recording facilities were of a breadboard type, assembled partly from components lent by Twentieth Century-Fox, and recordings were made on a projector with the arc operating to provide a continuous check on synchronization. Although this was scarcely a "studio" method of operation, the recordings so produced were of commercial quality and made it clear that the final proposal would make a commercially successful product.

The Simplex Single-Film Stereophonic Sound System for the reproduction of composite stereophonic sound film contains three major new units which are added to the basic Simplex Stereophonic Sound System. These are: the magnetic soundhead, the preamplifier assembly, and the power-supply switcher assembly.

Magnetic Soundhead

The magnetic soundhead, shown in Fig. 2, is mounted on top of the projector head, as shown in Fig. 3. This departure from the conventional location of the photographic sound pickup is not new, having been employed in some early sound-on-film proposals. However, since a different synchronizing distance between picture and sound was inevitable for magnetic tracks, a separation of 28 frames behind the picture was

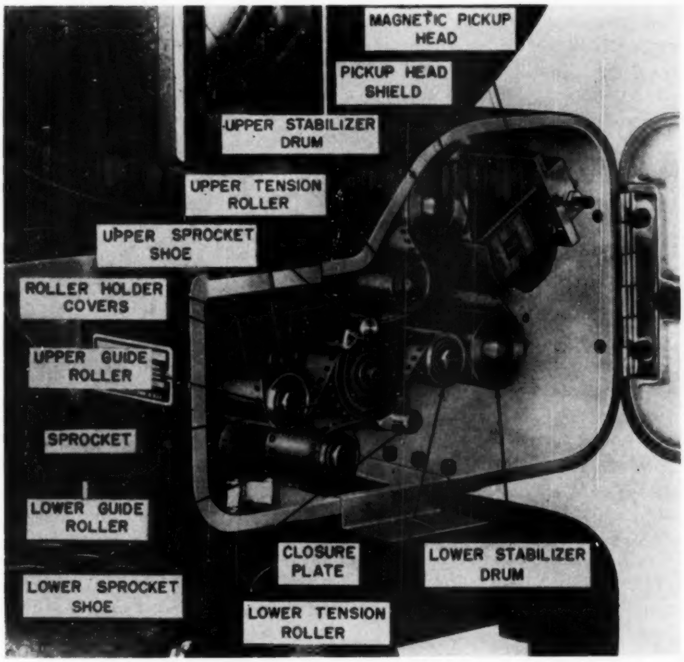


Fig. 2. Simplex four-track magnetic soundhead.

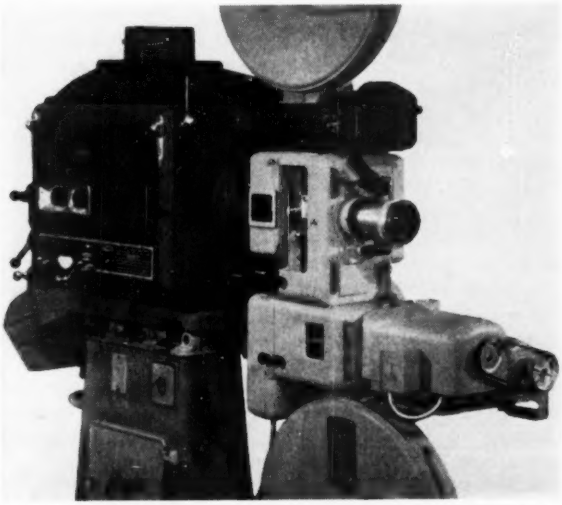


Fig. 3. Simplex four-track magnetic soundhead mounted on a Simplex XL Projector.

agreed upon so as to accommodate the various types of projectors in service.

Some of the advantages of the top-mounted soundhead may be listed briefly here:

(1) The photographic soundhead may be left unmodified. This carries the advantages that:

(a) The photographic sound performance need not be affected.

(b) A magnetic-photographic soundhead must have compromise performance, because the magnetic sound stabilizer must operate in the presence of head friction.

(c) A photographic soundhead cannot have many parts added to it without becoming excessively overcrowded.

(d) Any system which converts existing photographic soundheads for magnetic sound must provide for the conversion of an impractically large number of soundheads of all types.

(2) The magnetic-hum-field-sensitive sound mechanism can be moved far from the strong hum fields of motors and selsyns.

(3) The threading of the soundhead is done at convenient eye level.

(4) The film at the new magnetic scanning point has not been subject to the momentary frame deformation or buckling caused by the absorption of heat energy while in the picture gate.

The Simplex Magnetic soundhead adds only 4 in. to the overall projector height and does not affect the normal operation of the projector. Films with photographic sound tracks are threaded to bypass the magnetic pickup system and films with magnetic sound tracks may be threaded to bypass the photographic sound scanning system. The magnetic soundhead is entirely film-driven and uses a tight-loop stabilizing system to provide extremely uniform film motion. One function of the single sprocket is to maintain the length (and thereby the tension) in the tight loop. The filmpath is shown in Fig. 2, passing over two tension rollers and two stabilizing drums on whose shafts are mounted flywheels. To insure proper side guiding of the film, the upper stabilizer drum (directly ahead of the magnetic pickup head) is flanged. A tension spring beyond the pivots of the tension roller arms maintains the film tension, and a centering spring attached to one of the arms maintains the rollers centered.

A rotary viscous damper employing a sector of a cylinder rotating in a silicone fluid inside a cylindrical drum provides damping for the filter system. The damping is applied directly to one of the filter roller arms in order to avoid the backlash inherent in any mechanical linkage. The natural period of the filter is about $\frac{1}{3}$ of a cycle, and excellent flutter performance results.

Because the single sprocket acts passively, the filter system is well isolated from external disturbances. Such disturbances are "passed on" to the pulling sprocket by the soundhead sprocket, and the filter system exists in a sort of backwater or eddy off to one side of the main filmpath.

All parts of the soundhead which contact the magnetic coating on the film (except the magnetic pickup head) are of nonmagnetic material, including the stabilizer drums and shafts, which are of stainless steel.

The magnetic pickup head is mounted on a bracket which is held on a slide by a spring and a lock screw. This slide permits lateral adjustment of the head relative to the film, with a stop screw and lock nut for holding the correct location. Three set screws in the base of the magnetic head permit azimuth and tip adjustment of the head relative to the bracket, with the three head-mounting screws locking this adjustment.

An early form of an annealed mu-metal front shield, formed over a cold rolled steel form is shown in these

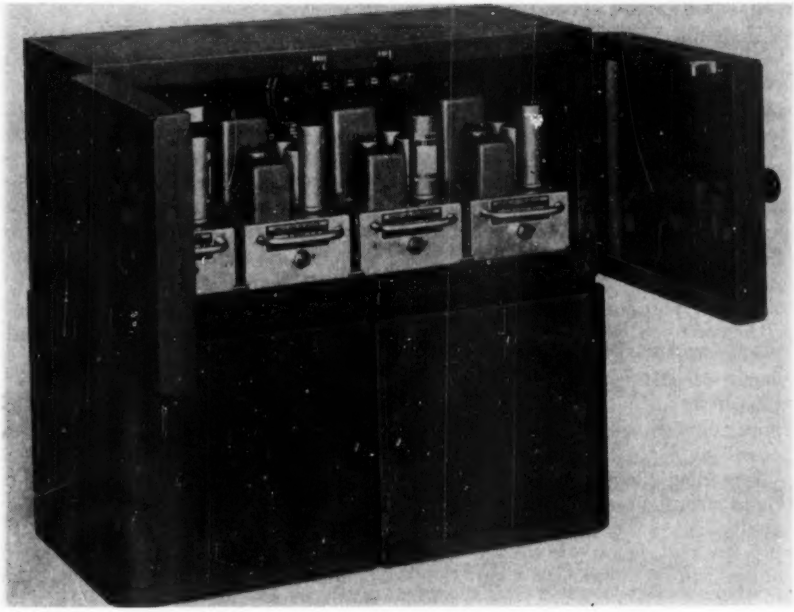


Fig. 4. Preamplifier cases for Simplex four-track magnetic sound system, showing plug-in preamplifiers.

Fig. 5. Power-supply switcher case for Simplex four-track magnetic sound system, showing one plug-in power supply and two plug-in effects switchers.

pictures. The present form of this shield permits quick removal of the shield for head cleaning and degaussing. For severe hum fields, a box shield which slips over the magnetic head and is held by spring tension is provided.

The magnetic pickup head is a Brush type BK1544-S1237, manufactured by the Brush Electronics Co. to reproduce film conforming to specifications supplied by Twentieth Century-Fox. The connections for the individual track heads and a ground are brought out to a Cannon type DA-15P plug mounted on the side of the head, and a mating plug and shielded harness carry the connections to a barrier terminal strip in the connection box on the front of the soundhead.

Threading the soundhead is simple. The correct loop length is automatically obtained by threading tightly with the sprocket pad shoes open, since a pin on one pad shoe operating toggle limits the movement of one of the tension arms. Closing the pad shoe releases the tension arm and permits it to perform its filtering function.

Preamplifier and Power-Supply Switcher Assemblies

This equipment is mounted in wall mounting cases of two types, but identical external appearance (Figs. 4 and 5). The preamplifier case mounts four plug-in preamplifiers, and the power-supply switcher case mounts one power-supply and two "effects" switchers. The electronic assembly for two projectors consists of two preamplifier cases mounting four preamplifiers for each projector and one power-supply switcher case. For a three-projector installation, one preamplifier case and one power-supply case must be added. Under these conditions, the second power-supply case contains one power-supply and one effects switcher, and a removable (not plug-in) dummy load for the unused part of the power supply.

Cannon type DPB twelve-pin plugs with twinax input connections are used for the preamplifiers, and I.P.C. type F-10A and M-10A connectors are used for the power-supply and effects switchers. Terminal blocks in the back of the mounting cases are connected by harnesses to the plug strips which are mounted on a channel strip. A power-supply case and a preamplifier case differ only in these plug-harness assemblies and the reversal of the mounting blocks for the plug channels.

The preamplifier is of conventional design, employing a 5879 and a 12AT7 tube. The 5879 is connected as a pentode, and is followed by an RC equalizing circuit. The 12AT7 is connected as a cascaded triode amplifier, with feedback over the two stages. A potentiometer in the feedback network provides an approximately 6-db gain adjustment. The input transformer is a UTC HA100X, connected for a nominal 50-ohm input impedance, and the output transformer is a UTC A-25 with plate current in the primary, the output being connected for a 500-ohm output.

For purposes of gain measurement, the head-source impedance is considered to be nominally 50 ohms. The dummy source which is actually used for measurement consists of a 6-ohm generator in series with a magnetic pickup head. For calibration, this source is terminated in 50 ohms and the power into this resistor is considered to be the signal delivered to a nominal 50-ohm load.

With the gain control at maximum, the gain of the preamplifier at 1000 cycles/sec is 75 db. At maximum gain, input short-circuited, the output noise is -45 dbm. The output signal at 1000 cycles/sec, from a 50-mil track modulated to 3% distortion is $+7$ dbm and for a 29-mil track at 5% distortion, $+1$ dbm. The distortion at $+8$ dbm output is less than 0.75% above 300 cycles/sec. At low frequencies, the distortion rises to 1.2% at 50 cycles/sec. The recording pre-

emphasis of 6.5 db at 50 cycles/sec, however, assures that the maximum level at 50 cycles/sec for 3% recorded distortion on the film, plays back at +0.5 dbm at the preamplifier output. At this level, the output distortion of the preamplifier is less than 0.5%.

The power supply is conventional and not regulated, with a two-section choke input filter. The d-c filament supply for the preamplifier delivers 600 ma at 19 v with a single-condenser filter providing 0.5 v peak-to-peak ripple. The filaments of the 5879 and 12AT7 are connected in series, with the 12 v connection for the 12AT7. Two filament supplies are provided in each power supply, each for four preamplifiers. 6.3 v a-c is also provided for the effects-switcher filaments.

As the preamplifiers are unplugged, successive sections of a series resistor string are unshorted to improve the regulation of the filament supplies.

The effects switchers perform the function of connecting the outputs of the effects-track preamplifiers to the power amplifiers driving the audience surround loudspeakers when a 12-kc control tone is recorded on the effects track and disconnecting these preamplifiers when this tone is absent. The purpose of this arrangement is to remove distracting hiss, crackling or crosstalk from the audience surround speakers when no effects signal is present on the effects track.

The switchers employ a tuned circuit to select the 12-kc control tone and apply it to the grid of one half of a 12AT7 tube which acts as a tuned amplifier for this tone. The tone is rectified in a voltage doubler and applied to the grid of the other half of the 12AT7 to control a plate circuit relay which controls the connection between the effects power amplifier and the effects-track preamplifier. A further tuned circuit discriminates against the control tone in the sound path.

The outputs of the effects switchers are connected in parallel, since the 12-kc control tones perform automatic changeover for this channel. The outputs of the three stereophonic channels for each projector are fed to Simplex AM-202 or AM-203 changeover boxes. The output of the effects switchers are fed to a Simplex AM-207 system selector box, which selects the route for optical and effects sound for single- or double-film stereophonic or optical sound. These units are parts of the basic Simplex Stereophonic Sound System which is not described here.

The Simplex Single-Film Stereophonic Sound System which has been described has the following minimum performance specifications:

System signal-to-noise ratio — 52 db
System frequency response (from CinemaScope multifrequency test film) — ±1 db 40–12,000 cycles/sec
System distortion at 3% recorded distortion level on test film — less than 0.75% total harmonics
Flutter (from CinemaScope flutter test film) — less than 0.2% one-sided peak.

The authors wish particularly to thank the following persons for their invaluable contributions in the development of the equipment described here: R. W. Burfeind, F. N. Gillette, W. D. Hay, R. L. Kenngott, and D. B. Shaw, all of General Precision Laboratory Inc.

Equipment for Stereophonic Sound Reproduction—Panel Discussion

JOHN K. HILLIARD, Moderator

E. K. Carver (Eastman Kodak Co.): What tension is required over the magnetic head, especially in the two cases where a combination sprocket is used? How great is the tension on the film in that isolated portion?

John G. Frayne (Westrex Corp.): It's approximately 400 g, in the closed film loop.

Skipwith W. Athey (General Precision Laboratory): I believe the actual tension in the film is of the order of 8 oz and the force against the head is of the order of 3 to 4 oz.

Dr. Carver: The thing that's bothering me, really, is the difficulty in running a combination sprocket, which is not suitable either for holdback or feed with a high tension.

Dr. Frayne: There's no problem if the sprocket is properly designed. In the Davis Drive, we have always recommended a sprocket-tooth base that nearly fills the sprocket hole in the film. This minimizes the "crossover" effect where the tension in the filtered film loop exceeds or becomes less than that in the external film paths. This crossover usually results in high flutter content at this point in the film running. In the Westrex CinemaScope head we use a base tooth dimension of 70 mils. We would like to use a base of 73 mils and completely fill the sprocket hole, but the film shrinkage prevents this. We refer to this type of tooth colloquially as the "fat-tooth sprocket."

Mr. Athey: I think we can confirm exactly that same effect. The sprocket form is of crucial importance. (We prefer to avoid the use of a full-fitting tooth, however, because the reproducing equipment must operate properly with shrunk film, as opposed to the essentially unshrunk film with which recording equipment operates.) In the early development we did not have sprockets of the proper pitch diameter and our flutter performance was therefore not very good. However, with sprockets of optimum pitch diameter, flutter due to tooth ripple is essentially eliminated over a normal range of film shrinkage. (The most prevalent causes of the "crossover" trouble are bent reel flanges, nonuniform friction of the feed-spindle brake, and sticky fire-valve rollers.) With properly adjusted equipment, the crossover phenomenon can be prevented throughout the run of the reel, and flutter from this source can be eliminated.

W. G. Hill (Ansco, Binghamton): I'd like to clear up just one point about this fat-tooth sprocket. Dr. Frayne speaks of a 0.70 base. May I ask what that is? What is 0.70?

Dr. Frayne: The sprocket-tooth base is 0.070 in.

Mr. Hill: So that dimension is intended to fit the narrow way of the hole?

Dr. Frayne: Right. Lateral positioning is not critical.

Mr. Hill: May I ask, then, about how many teeth in contact do you use?

Dr. Frayne: I don't recall exactly.

Mr. Hill: It doesn't allow very much for shrinkage.

Dr. Frayne: No, but there is no problem with film with normal shrinkage. Perhaps some other members of the Panel would like to comment on this.

This panel discussion was held on October 6, 1953, at the Society's Convention at New York.

Willy Borberg (*General Precision Laboratory*): About three or four teeth are in contact in our unit.

Dr. Frayne: I believe that in the Westrex design there are fourth teeth in contact with the film.

Loren L. Ryder (*Paramount Pictures Corp.*): I should like to ask Dr. Carver, if I may, what type of sprocket has been used in the life-test information recently published with respect to the new sprocket holes and sprocket teeth; and the second part of this question is to the Panel: What life tests have been made with the fat-tooth sprocket as applied to this new technique?

Dr. Carver: We have run life tests on only the intermittent sprockets. We have not yet been able to get hold of any soundheads to determine the effect of the sound-heads on film life. The narrow-tooth sprocket which we first used was ground down from the standard tooth width — it happened to be an 0.955-in. sprocket with a standard transverse pitch. That did not give quite as good fit as the special sprockets would. With sprockets of 0.955-in. diameter, that is a sprocket that is oversize relative to the pitch by about 0.8%, we got about four to six times the life that we expect on ordinary 0.935-in. sprockets, such as have been used so much in the past as intermittent sprockets. That is, we found that the increase in the diameter of the sprocket, leading to an increase in pitch and to a correct sprocket-tooth film-pitch relationship, increased the life of the film a very great deal. In fact, without the magnetic stripes on, which increased the friction, we got almost ten times the life. Now, we recommend 0.953 in. because it seemed that the 0.955 in. was going a little far, in case the film should shrink more and with a 953, after we got some sprockets specially made, we got equally good or better life.

Mr. Ryder: There is another question pertaining to these sprockets, and that is: If the new sprocket tooth and the new sprocket-size diameter improve the life of the film with the new sprocket-hole width, how much more does it improve the life of the old sprocket-hole size if we use the new sprocket tooth and new diameter?

Dr. Carver: Mr. Loomis is here and he can correct me if I'm wrong. I think that the old sprocket hole runs a little bit better with all sprocket teeth than the smaller sprocket hole. What I'm saying really is that if you have the right size sprocket, you're way out ahead of where you've been in the past anyhow. The small amount that the smaller sprocket hole takes away from your life, is a very small fraction of what you gain by the increased size sprocket.

John Maurer (*J. A. Maurer, Inc.*): I'm impressed by the fact that we seem to be moving forward in practically every aspect of sound quality, except with respect to flutter. This is a partial continuation of correspondence which I have had with our Sound Committee Chairman about test films. I would like to ask the Panel — anyone who is in a position to answer — what is the frequency spectrum of this flutter and why is it so hard to get the flutter in the recording below about 0.1%?

Dr. Frayne: In magnetic recording, as I believe I have pointed out in previous papers, we have not yet been able to get as low flutter content at high-frequency rates as in photographic. On the low-frequency end there's no problem, because we use the same film-pulling mechanism, the same filter system, but in magnetic recording we have to pull the film over a solid head. If you remember the old straight gates in photographic recording in 1928, they were not very good either. When we went to drum scanning, we had no frictional contact and we succeeded in getting very excellent flutter performance on photographic film. Now recording on magnetic shows an increased high-frequency flutter content over photographic. However, it's not entirely harmful, because the flutter rates are very high. On a typical flutter chart on magnetic you'll get excellent flutter performance until you get up in the 96-cycle region and then you may find values of the order of 0.10% and 0.15%. On a very good job, it may be as low as 0.05%. Then in the band, say, between 100 cycles and 200 cycles, the flutter may jump some more. In general, I would say that magnetic recording is inferior to photographic in the high-frequency flutter rates.

Mr. Maurer: Do I infer correctly that the real trouble is longitudinal vibration of the film past the head?

Dr. Frayne: Apparently so, yes.

Edward Schmidt (*Reeves Soundcraft Corp., Springdale, Conn.*): I should like to point out that this question of high-frequency flutter affects not only the application of magnetic film in the motion-picture industry, but other industries as well. I was thinking of the telemetering applications of FM work and there is considerable work being done by all manufacturers of magnetic products to reduce or cut down on the head-scrape — that's about the best term that we've come up with so far. Perhaps it's coefficient of friction of the coating to the magnetic head.

Dr. Frayne: I think that we did find that some manufacturers put out what they call a lubricated magnetic coating which does improve the high-frequency flutter performance.

George Lewin (*Signal Corps Pictorial Center*): Can anyone advise whether there is any individual adjustment on these multiple heads for head contact with the film?

Mr. Athey: With the Brush head, which we are presently using, there is no way in which the individual contact can be adjusted, other than that the entire head can be tipped. It may be that as a result of wear, this individual adjustment may become desirable. At the present time, the attitude that we have taken (and I believe the other manufacturers, too) is that if the filter system is properly aligned so that the tension is equalized between the two sides of the film and the contact surface of the head is flat, then for all practical purposes the tension and head contact are consistent across the film. It has been very difficult to catch up with the theaters on life tests. In other words, in 24 hr you can't gain more than about 10 hr over a given theater. Our knowledge of the effect of lack of individual track adjustment as it affects the life of multiple-track, composite film is, I'm afraid, rather elementary. The present head is potted in plastic and it would be somewhat of a problem to do individual adjustment of, say, track 2 relative to track 1 and track 3.

Mr. Lewin: I assume, then, that the adjustment for reproduction must be a lot less critical than for recording, because I know that in recording we probably would miss terrifically the absence of an individual adjustment for each head, since I don't think the film ever lies completely flat.

Mr. Athey: I think I can use this as an occasion to make the point that in the beginning of this development there was evidence that there was amplitude modulation as high as 50%, 50 mils away from a sprocket hole. This evidence was based on the fact that a 200- or 250-mil track had been laid down and then played back with a 50-mil sampling head. Under our present CinemaScope conditions the track is laid down with a 50-, or eventually, a 60-mil head (I believe it's still a 50-mil now, isn't it?). The tension is localized in the individual area that you are concerned with. It's not the same process as attempting to keep the film absolutely flat across the 200- or 250-mil head, at part of which the contact may be poor. When you simply try to keep it flat over a 50-mil contact area, the problem does not seem to be as great. At any rate, this is our estimate from the results we have had. For example, when we had pieces of film which had had the edge wrinkled so that there was a definite kink, after a recording had been laid down, we could not hear this kink going through the machine. If the film were erased and an attempt were made to re-record, we just got a large hole in the sound, actually before and after this kink, as the film bounced clear of the head. The contact is, of course, more important on recording, because of loss of bias and the like, than on playback. I believe that the localized tension in the narrow track eliminates many of the difficulties that may occur with wider tracks, where the film is relatively stiffer.

Mr. Lewin: My question wasn't so much whether the contact was uniform across the width of one head, but whether the film is going to lie flat enough so that when you got good contact in one head, you have good contact on the others, especially the ones in the middle.

Mr. Athey: Would you estimate that the contact was going to be poor on the edge or in the middle?

Mr. Lewin: Well, I would assume that if you have good contact on the two outside tracks, that the track inside, the one that's in the conventional photographic sound-track position, might tend to dish inward and have poor contact.

Mr. Athey: We do not have any proper evidence, but it is my impression that the situation is exactly backwards from that. However, perhaps some of the others have some experience with it.

Dr. Frayne: I was going to add that the only problem that we've had so far is with so-called tonying of the film.* If you get a film with a bad tony in it, then, of course, you get a very bad contact, but if the film is in normal condition then there's no particular problem.

Walter T. Selsted (Ampex, Redwood City, Calif. This statement read by Charles H. Wirth, Ampex Corp., New York District Office): "As most of you know, Ampex Corp. has recently developed studio and field recording equipment for the Magna Theatre Corporation. Recently we have developed a complete line of theater sound reproducing equipment designed specifically for the reproduction of CinemaScope pictures.

"During our work on these projects, we made extensive investigation of the relationship which pre-emphasis and post-emphasis bear in respect to weighted signal-to-noise ratio and distortion. The pre-emphasis and post-emphasis characteristics established through the NARTB were based on studies made relating sound-source energy distribution with saturation characteristics of magnetic recording media. The studies of energy distribution made by Bell Telephone Laboratories in 1929 were recently repeated by Ampex Corp., which found excellent agreement. Recently repeated tests confirm that the NARTB standard characteristics are an optimum compromise between unweighted signal-to-noise ratio and high-frequency tape saturation. Great improvement can be realized in the listening quality of narrow-track magnetic recordings now being introduced for motion-picture sound, if the record pre- and post-emphasis at high frequencies are reconsidered, placing more importance on weighted signal-to-noise ratio and putting less importance on occasional high-frequency compression due to magnetic saturation. In design of the equipment for Magna Theatre Corp., we appreciably altered the pre-emphasis characteristics in the recorder with a resultant improvement in weighted signal-to-noise ratio of better than 10 db. Recently, studies we have made indicate that, using similar techniques and suitably choosing the recording material, an improvement of approximately 16 db can be achieved on a weighted basis. These improvements in signal-to-noise ratio are primarily in the upper end of the audio spectrum where tube and tape hiss are the objectionable quality of which the listener is immediately conscious. The techniques we have used indicate an improvement of at least 7 db throughout the rest of the spectrum."

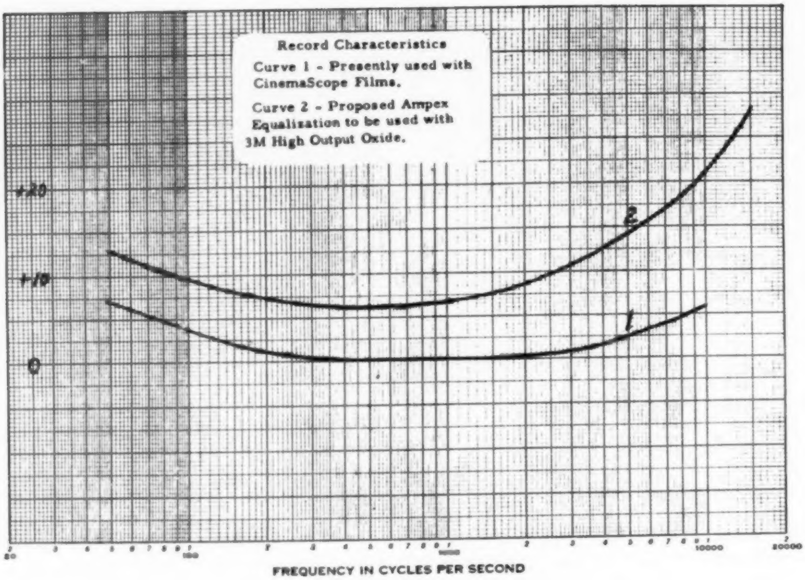
Ampex has had such good results with these recently developed changes in equalization that we should like at this time to propose that the Ampex equalization characteristics be accepted as an industry standard as well as a standard adopted by the Society of Motion Picture and Television Engineers.

With your permission, I should like the opportunity to show you the two slides I have brought with me on which the equalization curves which Ampex proposes are shown. The first slide shows the record amplifier equalization characteristic. The one presently used by the motion-picture industry is shown on Curve 1, the only exception being that the low-frequency pre-emphasis used with CinemaScope films has been added (Slide 1). Curve 2 shows the increase in high-frequency pre-emphasis which we find is not only acceptable but highly desirable, and the 6-db spread between the two at low frequencies merely illustrates the approximate increase in output from the tape realizable by means of the new oxide developed by Minnesota Mining.

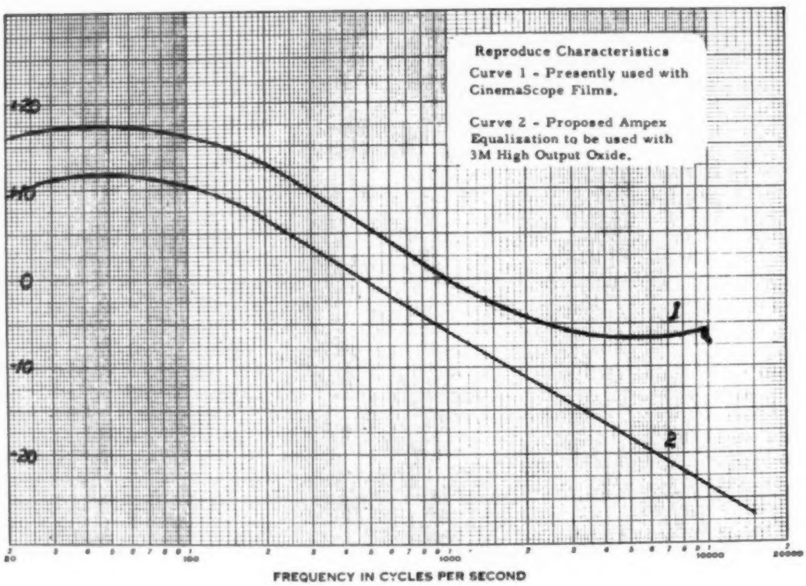
Slide 2 shows the necessary playback equalization curves to complement the record characteristics in each of the two former cases. As you will notice, the spread between the two curves beyond 1000 cycles increases quite materially. Since it is in this region where the most audible hiss occurs, the improvement in signal-to-noise ratio at any particular frequency is approximately equal to the spread between these two curves.

We wish to recommend these Ampex

* Fluting or waviness along the edge of the film, usually on one edge only but sometimes on both. See *Common Causes of Damage to 35mm Release Prints*, Motion Picture Film Dept., Eastman Kodak Co., Rochester 4, N.Y.



Slide 1



Slide 2

equalization curves to the industry as a standard for motion-picture sound recording.

I would like, at this time, to make a motion that a copy of this statement be referred to the Magnetic Recording Subcommittee for evaluation and adoption.

Mr. Hilliard: There's no motion necessary. It will be submitted and I can assure you that there will be a very lively discussion on this matter, because pre- and post-equilization are not new with any part of the motion-picture industry and you can anticipate that it will be fully discussed tomorrow in the Standards Committee. The reason for reading this communication at this time is so that those members who are interested and wish to discuss it are certainly invited and urged to attend the Standards meeting tomorrow and go over this particular item as well as many of the other things that are to be discussed.

Malcolm G. Townsley (*Bell & Howell Co.*): The Subcommittee on Magnetic in the morning is a good place for that.

Mr. Hilliard: Yes.

Richard Norton (*Warner Pathe News*): I'd like to ask you gentlemen, jointly, if a definite standard has been arrived at for the separation of the picture gate and the actual soundhead. Is it standard between all your different soundheads or does it vary from one manufacturer to the other? Would that preclude the possibility of using a Super Simplex head with an RCA Stereophonic Reproducer? And likewise other combinations, or would a particular soundhead be required to complement the same manufacturer's picture head?

Mr. Athey: Obviously we designed our soundhead to fit directly on the most expensive and best Simplex projector. It is, however, also designed for adaptation to other projectors and I believe that is true of the rest of the people here. I believe that the Ampex device is designed for the Simplex XL, can be adapted very simply to the Simplex E7, and with adaptor plates, to other projectors. In addition to projector adaptation, there's another little problem which is adaptation to 18-in. and 25-in. magazines of various manufacturers, but I believe that in one way or another all the manufacturers have managed to cope with this problem.

William Youngs (*International Motion Pictures, Washington*): Is this system compatible with 3-D? In other words, would the addition of the stripes on the film cause an increase in thickness, which in turn would cause film distortions in matched prints? In particular, would a theater be still required to install a magnetic dummy for reproduction of stereophonic sound on 3-D, or could this same thing be worked on that?

Mr. Ryder: I believe this procedure is not even compatible with standard 2-D. The system that has here been suggested is based upon a picture placement and picture centerline which are different from the standard. If a standard picture were to be projected on the equipment when it is lined up for this system, the centerline of the picture would not align with the centerline of the screen. This is a serious problem.

Mr. Athey: Do you mean by that, that with the higher accuracy required of 3-D pictures for minimum eyestrain and the like, the mechanical changes caused by the stripes might cause some defect in projection which would affect the 3-D effect?

Mr. Youngs: Yes, I do. You know, the air getting in between the layers of the film, and the resulting warpage on it and your film going in and out, further aggravation caused by the high-intensity lights and sometimes film stored on trucks just overnight, or in film vaults when the prints are not in use, absorbs moisture.

Mr. Athey: Of course, we do not have very extensive experience with these things. I would, however, suggest, that the amount of light that is being poured through CinemaScope films to get a bright picture on a big screen is enough to cause as much distortion, if it is going to occur, as the fight for light with 3-D. It is my belief that the critical nature of the anamorphic lens system is such that you can tolerate very little more, and perhaps less, distortion in the CinemaScope process than in 3-D before film flutter or out-of-focus becomes very serious. This is strictly a personal observation from many hours spent in a number of projection booths in the last few weeks.

E. S. Carpenter (*Escar Motion Picture, Cleveland*): Have there been experiments

in lacquer-coating the film or the sound stripe?

Mr. Schmidt: I rather doubt that any normal lacquer coating over the sound track would be useful in any respect. Magnetic recording depends on intimate head contact for optimum results, and anything that you put on the top of the track will interfere with your head contact.

Mr. Carpenter: How much tolerance do you think is allowed?

Mr. Schmidt: Zero.

Mauro Zambuto (Italian Films Export): Have any tests been made to find out exactly what the performance is of the old-fashioned sprocket-hole film on the new type of sprockets?

Dr. Carver: In the very beginning, I believe that Twentieth Century-Fox realized that any new sprockets they made would have to run at least as well on film with standard perforations as the old sprockets. It turns out that if you do not increase the diameter of the sprocket you get slightly worse results, but if you use an intermittent sprocket with a diameter of 0.953 in. you get at least five times as good results as far as wear and tear on the film goes as you would with a 0.935-in. sprocket such as is ordinarily used. You also get better results than if you use a 0.943-in. which is the ASA standard. The 0.953-in. sprocket more than compensates for any decrease in wear you might get with the narrower teeth. Does that answer your question?

Mr. Zambuto: Thank you. It does as far as wear and tear are concerned. But what about the stabilization of the film drive? For instance, you don't have any variation in film positioning both as far as sound track and picture are concerned?

Dr. Carver: I can't answer on the sound track, but I can see no reason why we should. I think I'll have to ask Mr. Loomis to say if he has noticed any increased weave on the picture with the narrower teeth? I think he has not.

H. A. Loomis (Eastman Kodak Co.): We haven't projected any pictures on the wear tests, so we really don't know.

B. C. Passman (International Projector Corp.): Mr. Athey has described briefly the effects-switching system used in the GPL system. I wonder if Dr. Frayne or Mr. Phyfe would care to comment on their systems.

Mr. Phyfe: We have a suppressor system now in operation in our labs in Camden and we have it in production as well; we have used the circuit originally suggested by Twentieth Century-Fox and find it very satisfactory.

Dr. Frayne: I can state that we had a working breadboard model about two weeks ago and will probably be in production shortly. Incidently, we have been having some debate with Lorin Grignon as to the feasibility of changing over — instead of having the 12-kc on at the same time as the signal, to have instead the 12-kc on during the silent period. It just reverses the operation of the circuit. That was still under debate when I left.

Mr. Hilliard: I'd like to comment on that last remark from Dr. Frayne. We have had a great many changes back and forth here and the system which we are presently making — that's International Projector and General Precision Laboratory — is operating, I believe satisfactorily with the 12-kc on during the sound effects. It seems undesirable to make a further change unless it's necessary.

Edward S. Seeley (Altec Service Corp.): Was it Dr. Frayne's proposal that, although *The Robe* has been recorded with 12-kc present when effects are to be reproduced, thereafter succeeding pictures should be recorded differently and that the equipment now in use, and there is quite a little of it and it is going in very fast, should all be replaced with equipment that will work in the opposite direction?

Dr. Frayne: It's a very simple change to make in the field.

Mr. Athey: Maintaining the 12-kc during the effects sound is certainly, in one sense, the hard way to do it. It is my impression from the demonstration recordings that we make for Fox that the modulation noise from the 12-kc, even though the 12-kc is not audible, is a disturbing factor. Unfortunately, and this is just my guess from not very exact results, as the frequency gets higher, any errors in recording contact become more impressive in their effect on the signal. What we get if we do not have perfect contact is a modulated 12-kc modulation noise. However, there are great system simplifications made

possible by the present arrangement. As a matter of fact we do not change over our fourth track at all from projector to projector. This, as far as we are concerned, is a great simplification. We have had several phone calls suggesting turning it around the other way. We have, unfortunately, also had expressions of the idea that maybe the 12-kc control signal would turn on the left speakers, a 14-kc control signal would turn on the middle speakers, the lack of a control signal would turn on the right speakers and something like 13-kc would make the whole system dead. I trust that we will have a little time to develop this before we make any decision.

Mr. Hilliard: Do any of you have any recommendations on a higher frequency that might be used for this control or some other frequency that you think could switch it, other than the immediate area around 12-kc?

Mr. Athey: No.

Dr. Frarne: I thought, perhaps, that you might be interested in how the prints were made on this system of recording. We were asked by Twentieth Century-Fox to develop what was called a magnetic printer. What we have supplied and what is being used to turn out the prints for *The Robe* consists of a master four-track reproducer, which reproduces from four master magnetic tracks. Each track is 150 mils wide on fully coated film. We had to design a special four-track head for this operation. This reproducer is equipped with complete reproducing facilities including equalization so that we get a 1:1 transfer as far as frequency characteristic is concerned. Then the output from this reproducer is fed to a battery of five quadruple-track recorders, running at normal speed and these recorders are in cabinet-type racks, or in a special cabinet, which contains complete recording and reproducing transmission facilities.

The film runs at standard speed, at 90 ft/min. It was originally considered to run the film at a higher speed, but because of the desirability of monitoring to permit the operator to monitor at will at any one track in any one machine, it was decided to retain the normal speed at 90 ft/min. These five machines are tied together in interlock, using a composite synchronous interlock type of motor which does not require any distributor. Any one machine can be run individually for test purposes on the sync-motor basis or any group of machines can be tied together by simply throwing a switch on each machine to run in interlock. The five recorders will eventually be equipped with 60-mil heads to lay down a 60-mil track. Due to shortage of such heads, the present prints on *The Robe* are being made with 50-mil tracks, which is the same as the reproducing. Obviously, from the weave standpoint, it's desirable to have the recorder track wider than the scanning head in reproduction. This system is working very well. There are other bottlenecks in reproduction, but not in the printing operation.

Mr. Lewin: I've noticed in making distortion measurements on magnetic recordings that when you get up into the high frequencies you often get distortions that don't seem to show up on the meters, but your ear tells you they're there. Apparently they are heterodynes that are set up between the high frequency and the bias frequency, or possibly for some other reason; but for that reason I feel that you have to be very cautious about increasing the amount of high-frequency boost in your recording, because even though the frequency response might look as though you made an improvement and the noise measurement might tell you that you got less noise, you still might have a poor recording, because it just doesn't sound as clean on the high frequencies due to this heterodyning effect.

Mr. Hilliard: This problem has been considered at great length for several years, both from a radio-channel and recording-studio standpoint. The NARTB curve referred to 16 db of pre-equalization and then, in examining the frequency contents of the Academy Research Council test reel, it was found that the 100% modulation point in speech was repeated more often in the range between 2000 and 6000 than any other region; and so I think that it behooves us to approach the degree of equalization that is proposed in a very cautious manner, because of the nearness of the microphone in the case of recording and the situation of sound effects and other frequencies that are well up in the spectrum of increased amplitude if you use the equalization characteristic.

Mr. Zambuto: Sometimes measures of increased signal-to-noise ratio which can be made on certain frequencies will not tell the whole story, particularly when you consider recording of speech. This is due to the effect you were just mentioning, that is, spectral distribution of energy in speech. I happen to have made some experiments on this and we had some rather interesting results, particularly regarding the spectral distribution of speech in different languages. For instance, in Italian we found that we have more middle frequencies around 2500 to 4500 than you have in English, the latter being richer in higher frequencies. Therefore, it often is the experience of Italian mixers that if you boost that particular range of middle frequencies, you have to pull down your average level in order not to overmodulate, and therefore you reach 100% modulation at a lower power level; as a result you lower your expected signal-to-noise ratio considerably. I think this effect should be kept in mind in evaluating the advantages of a new standard.

Mr. Hilliard: It has been my opinion, and I think it is being confirmed currently, that the amount of equalization proposed is as drastic as was used in the NARTB curve and it has gradually been dropped. The AES disk recording and reproducing curve indicates the trend, and I know from experience in motion-picture sound recording that this amount of equalization was tried originally and has been dropped because of the fact that you would penalize yourself in overall level or overload, or a combination of both.

Mr. Ryder: At Paramount, from the inception of magnetic recording, we have used pre-equalization in the amount of between 10 or 12 db at 8000 cycles. We have had good success recording that way and I should say far less trouble than we had in other recording activity. At Ryder Services, when I do outside work I comply with the standards of the industry, I do not use pre-equalization. So I have one plant, namely Paramount, with pre-equalization; another plant, Ryder Services, without pre-equalization, and believe me, I prefer the pre-equalization. I'm on the side of Ampex.

If there is varying contact in recording and reproduction, the effect is not as bothersome in my work with pre-equalization as in my work without pre-equalization. I am very much in favor of pre- and post-equalization, especially as we diminish the width of the sound track.

Dr. Frayne: I believe since we have supplied some equipment to Paramount Studios I can elaborate a little on Mr. Ryder's remarks. I'm quite sure that Mr. Ryder continued to use the same pre- and post-equalization on magnetic that Paramount has used on photographic recording and which we had supplied to him. That equalization is not nearly so drastic as Ampex proposes. It flattens off, as a matter of fact, around 6500 cycles, and at least as originally supplied it does not exceed 12 db. Now, also bear in mind that the experience at Paramount is with original recording, not on release. As far as I know, Paramount has not released any film with that degree of pre-equalization, because the theaters couldn't play it back. You'll notice that the Research Council is proposing some pre-equalization. The recording characteristic was not shown here today, but it suggests about 3 to 4 db pre-equalization at 8000 cycles only so that we can get a fairly flat overall response with the proposed reproduction characteristic of the preamplifier.

Mr. Ryder: We have actually tried this out in the theaters, and the first magnetic installation for theater reproduction at the Chinese in Hollywood was made for Paramount and under our supervision. The Chinese happens to be one of the key theaters in Hollywood. We have done a fair amount of experimenting in this field, and we still think that we're right, but this is the type of thing that makes for good horse racing and we like that, too.

Dr. Frayne: I'd like to add, that in the Chinese installation they were 200-mil tracks which have a slight advantage over the coated 50-mil track.

Mr. Athey: Apparently the spectrum problem of low-frequency pre-emphasis does not seem to worry anybody very much. I assume that something is supposed to give in the system at high levels. You may notice that I pointed out that in a sense we take advantage of it in order to reduce some of the requirements on our amplifiers. It seems to me that the real reason for low-frequency pre-emphasis,

which I don't believe has been made too clearly here, is that we have a perfectly fantastic hum problem. I have made some very crude calculations here and I believe that for a 50-db signal-to-noise ratio, the hum signal must be less than −144 dbm at the input of the preamplifier. This is a fairly severe hum problem and I therefore hope that we do not give up more than a db or so of the present low-frequency pre-emphasis.

Mr. Wirth: I would like to comment on some of the points that have been made. For one thing, I think that the concept of using high-frequency pre-emphasis to compensate for inefficiencies in head design or difficulties thereof is one of the evils of the magnetic recording industry.

The amount of pre-emphasis that Ampex used for the Magna Theatre Corp. was not tied down to any particular set of specifications, since it was a development system which we hoped would be superior to anything that existed before. It therefore gave us the opportunity for experimentation to our heart's content with the variety of possible paths available. We made a great number of narrow-track listening tests with different pre-emphasis characteristics in order that our conclusions would be based on CinemaScope conditions. I think that's the whole key to this discussion: we are now dealing with very narrow track magnetic stripes. With the replaying of CinemaScope films, no doubt, we will be able to get some quantitative information as to deterioration of signal-to-noise ratio due to the rubbing-off of the oxide, and other effects.

We're not saying that this proposed pre-emphasis characteristic is, by any means, the last word, but we're certainly interested in finding out what other people think about it.

Mr. Athey: Was this equalization for a half-mil playback gap? Since our present system is designed for the half-mil gap we wouldn't like to go to a larger gap.

Mr. Wirth: A ¼-mil gap is used.

Ralph H. Heacock (RCA Victor Div., Camden, N.J.): There are several minor things that have come up in the field about which there may be some confusion. Someone asked about the adaptability of the various manufacturers of button-on units to various projectors. I think broadly and from an engineering viewpoint, certainly all manufacturers plan to have their units adaptable to any type of projector that may be available in the field, but from a practical viewpoint at the present time we are so very busy producing equipment, that it may be that we haven't gotten around to making the necessary adaptor plates for some particular projector and, because of that, a report gets around that a certain unit will not work with a certain type of projector. Well, that may be only because that particular adaptor plate is not available to meet the necessary close opening date of a particular theater, so that probably, in the course of the next few weeks, it will be correct to say that any one of the units, at least to the best of my knowledge, will work with practically any one of the projectors in the field.

There was one other question that was asked by someone about the standardization of sound take-off with relation to picture take-off. It's my understanding that the sound lags or follows the picture by 28 frames, so that there is actually a lag of 28 frames with all of the button-on types of sound heads.

One other question that came up: someone asked about the effect of the narrower sprocket teeth when used with the conventional sprocket hole in the film. In general, the studio guides of the projector are the determining factor for lateral weave, so that even though the tooth is narrower than has been the practice in past years, the studio guides will still be the determining factor in lateral weave. It would, therefore, be my guess that it should not be any worse with a narrower tooth than it has been in the past with the standard tooth. There has been a lot of discussion about the new CinemaScope sprockets. That, I think, is probably a matter that comes under the Film Projection Practice Committee. Our meeting is at 2:00 o'clock on Thursday afternoon and we would very heartily welcome anyone who wants to come in and express any comments on the new types of sprockets, the root diameters and any other things that have been revealed in work of, say, the last six months, so that we can have the value of your experience in our Committee meeting.

Mr. Hilliard: What do you mean by studio guide?

Mr. Heacock: It's a long guide which is located in the film trap on each side of the film. In general, these are adjustable, so that if we say that a 35-mm film would be the distance between my two hands, this guide against which the edge of the film moves, is stationary. This one is adjustable, so that you adjust this guide to give you the steadiest picture possible, taking into account the variation due to shrinkage in the width of film. It is that adjustment that is generally the determining factor in lateral weave of the film in the film trap.

Mr. Zambuto: I asked the question about the different sprocket holes and lateral weave. There happen to be a certain number of moments in which the lateral guides fail to be the determining factors. Most of the time, when a splice goes by, you find the lateral guide fails to be the determining factor. But I was thinking of something else. It's everybody's experience that when the film is a little warped, or the perforation a little damaged, you find that the film is not correctly fed to the lateral guide. In such irregular feeding the tooth may easily become the limiting factor, by determining the strain on the lateral guide.

Mr. Heacock: I believe that at the instant that a film splice or some other irregularity occurs in the film trap, that the conditions may be quite unusual. But, of course, that's an extremely small percentage of elapsed time and I still feel that, whether you have the CinemaScope width of tooth or whether you have what has been our old standard width of tooth, you will still find that studio guides are the determining factor and it would be my guess that the situation might not be seriously different with the CinemaScope sprocket just for that instant, as compared to that when the standard sprocket is used. However, any other comments will be welcome.

Magnetic Head Wear—Panel Discussion

JOHN G. FRAYNE, Moderator

Editorial Note: "Ferrite-Core Heads for Magnetic Recording" by R. J. Youngquist and W. W. Wetzel, presented at the same Convention session as this discussion on magnetic head wear, has not been released for publication. The tentative conclusions put forth at the Convention have been withdrawn because continuing tests on ferrite-core heads have not borne out the earlier hopes.

At the end of the discussion, Dr. Frayne called for all concerned to add data when they received the draft of the discussion transcript.

Edward S. Seeley (Altec Service Corp.): First, who has seen operational or performance evidence of head wear: and second, what has been the nature of the performance change as a result of wear?

This discussion was held on October 9, 1953, at the Society's Convention at New York, with John G. Frayne as Moderator.

John G. Frayne (Westrex Corp.): I have seen physical evidence of head wear.

Mr. Seeley: How about performance evidence?

Dr. Frayne: Yes, we have noticed change in performance, particularly with respect to high-frequency response and erratic contact. I have no exact figures, but that we have head wear cannot be questioned. It is our estimate that with Westrex magnetic heads used in studio recording and reproducing equipment we obtained somewhere between 3,000,000 and 5,000,000 ft of wear without any serious changes in characteristics.

R. H. Heacock (RCA Victor Div., Camden, N.J.): We have one actual operating theater experience that was of interest to us. This was in the first installations of double-film systems that were made with

Interstate down in Texas, when they led off immediately following the opening of *The House of Wax* here in New York. After a considerable period of time had elapsed, we had the same RCA service engineer, who had made his measurements on original installation, return to the theater with the same equipment and make another set of tests jointly with Interstate engineers. After what we estimate to be approximately 6,000,000 ft of film travel, we found that lowering of the output level was, from a practical viewpoint, negligible; and the wear was not visibly apparent. That's the only specific case that we know of where we feel the results were accurate enough by virtue of having the same personnel, the same test equipment, the same units and an identical check made. Frankly, the results have surprised us. We didn't expect that we would be able to run 6,000,000 ft of film without having more difficulty than we have experienced in that particular theater.

Dr. Frayne: How much of a factor might the tension on the films be, in this case?

Wallace V. Wolfe (*RCA Victor Div., Hollywood, Calif.*): It is significant in that connection that this is a soft-loop type of machine. The pressure on the head would probably be somewhat lower than would be the case in the tight-loop machine. But exactly what it measures I don't know.

Dr. Frayne: Is that a full-coated film or the CinemaScope film we're talking about?

Mr. Wolfe: That's a full-coated film.

Mr. Heacock: This is a typical double-film system with separate sound coating. One other comment: we made a number of magnetic reproducer heads to have them available for field maintenance of our button-on soundheads. I don't believe we've had to use any of these reserves.

Mr. Wolfe: As to wear of heads in studio equipment, we find these things happening. The inductance of the head does go down as it wears; this is an obvious fact, and significant for these reasons. The frequency characteristic is a function of the bias current; and the bias current, in turn, is a function of the inductance of the head. Consequently, as the head wears, the frequency characteristic changes. The frequency characteristic can be brought back by appropriately changing the bias current.

[See: Kurt Singer and Michael Rettinger, "Correction of frequency response variations caused by magnetic head wear," *Jour. SMPTE, 61:* 1–7, July 1953.]

Skipwith W. Athey (*General Precision Laboratory*): The basic problem that Mr. Heacock described, and which, I believe, is the major concern as far as CinemaScope and double-film systems are concerned, is how much wear the theater gets out of the film on playback rather than the recording situation. I don't think many of us can get too concerned about the cost of the manufacture and operation of the recording equipment, because so few of us can see those dollars slipping away; but if the theater owner has to replace heads at a great rate, then that is of great concern. I have not had enough experience with wear on CinemaScope film to say what the effects of wear are. Am I correct that we would normally expect an increase in output with wear because of the reduction of the inductance of the head? This is for playback only. And am I not correct that unless resonance in the amplifier is changed in a major way we should expect an increase rather than a decrease in high-frequency response?

W. W. Wetzel (*Minnesota Mining and Mfg. Co.*): It's my opinion that the only two things which affect frequency response are bias effect on record and the gap effect on playback. Now all heads are constructed with a certain 20 to 25 mils of magnetic material which can wear away before the gap starts to widen and I don't believe we expect a change in frequency response resulting from that wear until it begins to get down into the V-shaped lower portion of the head. Then the gap widens. You do lose frequency response quite rapidly.

Mr. Athey: May we expect some low-frequency effects as wear changes the effective gap?

Dr. Wetzel: I think that they wouldn't be adverse, since you're increasing the length of gap. What you'd be afraid of doing is getting those funny little humps.

Mr. Athey: Or moving them too violently.

Dr. Wetzel: That's right.

Mr. Athey: Because they're certain to be there anyway.

Dr. Wetzel: That's right.

Mr. Athey: Some experience can be reported for the General Precision Laboratory

CinemaScope "penthouse" reproducer. At the Roxy the film has run for three weeks. For the first two days of this run, only two projectors were used; then the third projector was put in service. The Roxy is running six shows weekdays and four on Sunday — 40 shows a week. The picture is about 15,000 ft long. So about 800,000 ft of film have gone through the installation.

I have seen samples of film which had run almost three weeks, and the film isn't a very attractive thing, mechanically speaking. The burnished surface of the track generally looks as if you couldn't get anything in the way of decent sound out of it, but it continues to deliver decent sound and there appears to be no appreciable wear or damage to the film itself after this period of time.

Even in the laboratory you can't catch up on the theater very much in a life test because there are only 24 hours in a day. Most of us haven't had a head that we could put off to one side and run for a life test. I think we're just about getting to the point where we might think about that. Our only life test is usage in the field.

E. K. Carver (Eastman Kodak Co.): I've heard more worry about the narrow track wearing a groove in the sound head that overlaps it than about the wide tracks wearing the narrower heads down smooth. Is there anything to that?

Dr. Frayne: Yes, there probably is. Of course, in the CinemaScope system, three tracks are wider than the associated heads and this problem does not arise. It does arise on the fourth, or effects, track where the track is narrower than the head and the problem of the narrow track wearing a groove in this head is a reality. Is that correct, Dr. Wetzel?

Dr. Wetzel: It is hardly necessary for me to agree with it. RCA engineers presented at the SMPTE meeting in Washington a paper which was later published in the *Journal*, which shows the effect of half-track wear on mu-metal heads. It's very definitely present. [G. A. Del Valle and L. W. Ferber, "Notes on wear of magnetic heads," *Jour. SMPTE, 60:* 501–506, Apr. 1953.]

Malcolm G. Townsley (Bell & Howell): Most of the conversation about stepwise wear due to narrow tracks on wide heads has occurred in the 16mm field where there is quite a lot of 50-mil track used on 100-mil heads, with a good deal of worry about the wear effects. At the meeting in Washington the RCA data, to which Dr. Wetzel referred, were presented; there were some verbal data given by Bell & Howell and I think a comment by one of the Reeves Soundcraft engineers has later been confirmed by our own results. He said, in effect, that the dirt on the film contributes at least as much and perhaps more to wear of magnetic heads than the oxide coating itself. Usually you can see a slight difference in pattern on a head that's been run a great deal with 50-mil track, but after you develop this slight difference in pattern, the whole head wears down quite uniformly. We have just finished a set of tests in which we ran a 100-mil head with 50-mil track, replacing the track often enough to overcome the burnishing effect, because, as a film is passed continuously over a head, it burnishes itself and doesn't wear the head so fast anymore, and the performance of the head when tested with 100-mil track was substantially unimpaired at the end of 1100 hours. Now 1100 hours corresponds to something over 2,000,000 ft of 16mm film. (Note: this head has now (Nov. 4) run 1400 hr.)

E. W. D'Arcy (De Vry Corp.): I think the point that Mr. Townsley brought out is very pertinent about wear on the head. We were not concerned with regard to wear on the head as much as damage to the area adjacent to the magnetic track, and there certainly is enough wear to cause damage to it.

Dr. Frayne: I would like to add that in our organization on the West Coast we have started a systematic study of head wear with CinemaScope tracks, and information from this study should be available within a few weeks. I shall be very happy to add our findings to this discussion when it appears in the *Journal*.

Additional comment by Dr. Frayne,
Submitted November 5, 1953:

[A life test of a Brush BK-1544 CinemaScope Head in a Westrex R9 stereophonic reproducer has reached 900,000 ft of film. The film tension in the R9 averages 500 g in the upper and lower film paths, and with 15° wrap this equals 130 g pressure against the magnetic head. The head wear at the gap averaged $3\frac{1}{2}$ mils for the first 100,000 ft of film and has diminished in

rate so that at the end of 900,000 ft it averaged 11 mils, but with a spread of about 5 mils between individual heads. The BK-1544 Head has a depth of about 20 mils at the gap, thus leaving an average thickness of 9 mils of mu-metal remaining at the gap. The 8000-cycle response dropped by an average of about 3 db from the initial value at the end of 300,000 ft, then rose to equal the starting point at 600,000 ft and then dropped about $1\frac{1}{2}$ db below the starting value at the end of 900,000 ft.

[Film to head contact wear has not appeared to present a problem up to the present time. The inductance of the heads appears to diminish from the original value. It would seem that the head under test would continue to give reasonably satisfactory service for at least another million feet.]

Dr. Wetzel: I might add some rough calculations that are becoming apparent during this discussion. Let's take the 3,000,000 to 5,000,000 ft, which is approximately correct for the wide-head wear. Kurt Singer, Dr. Frayne, quite a number of people in the industry, appear to agree with that value. That means somewhere between 500 and 1000 hr. of actual machine operation. Let's assume that you have two projectors operating, two heads to wear. You're switching between these and you're operating over a period of 12 hr. That means 6 hr per day of actual head wear. Seven days a week means 42 hr per week and in 10 weeks it seems to me you might begin to expect a little trouble. Certainly I would expect it in 20 weeks.

Dr. Frayne: Along the same lines, I hope these optimistic predictions about head wear will not deter Minnesota Mining or other companies from their program of developing ferrite heads. It is well to remember that in standard photographic sound tracks the optical system was good for an indefinite operating life. Once in a while a lamp will burn out but a lamp replacement is relatively cheap. Compared to this, a 4-track magnetic head is going to cost — well, anywhere from $75 to $125. This presents a very serious economic problem to the theater owner and I am sure we all hope that somebody will come up with a successful ferrite head that will have an extremely long life.

Mr. Seeley: I wholeheartedly agree; but, in the meantime, we have to continue using the heads we have and are currently receiving in the field. We in the service companies are very much concerned over this matter. Most of the remarks have related to visible effects of wear. Of more interest are performance effects. I have assumed that wear would possibly produce a slow increase in mid-frequency level and in addition some slight decrease in reproduced high-frequency level due to increase in resonance frequency resulting from reduction of inductance. There will also probably be effects resulting from changes in the relation of the film to the gap.

John K. Hilliard (Altec Lansing Corp.): Most of the magnetic heads are designed for a 30-ohm circuit. It would appear that since the head inductance is decreasing, there could be a tendency to have a resonance at a high frequency because of the leakage inductance in the input transformer. This is caused by the fact that as you lower the impedance of the generator or driving transformer, the effect of the leakage inductance becomes more of a factor and would vary with the type of input transformer used. In some cases this will be of only theoretical importance, but with input transformers having a very high leakage value, it may cause a marked peak in the high-frequency end.

Col. Richard H. Ranger (Rangertone, Inc.): I can't give you any information on magnetic film, but I think the reaction would be quite similar on $\frac{1}{4}$-in. tape. We get anywhere from 15,000 to 20,000 hr on a head, but the thing that disturbs you when it does wear is dropouts. In other words, you actually lose contact, and once you do that, there is nothing but to get a new head or refinish it. The frequency changes are, generally speaking, immaterial.

Portable 16mm Arc Projector Adapted for 3-D Projection

By J. J. HOEHN, A. J. CARDILE and RALPH A. WOODS

A new portable arc projector for 16mm film, consisting of five luggage-type units, and its modification for 3-D projection, is described.

The RCA Porto-Arc 16mm Projector is designed to provide sufficient light and audio-power output to handle larger screen sizes and audiences than can be accommodated with projectors using conventional incandescent-lamp light sources. The design was made possible by the development of a dual operating-range 16mm arc lamp and associated rectifiers small and light enough to justify the use of the term "portable." This lamp has been integrated into an overall projector design which allows the equipment to be separated into readily portable units. For example, the arc lamp is easily disconnected from the projector mechanism, and both units merely lift off the pedestal-amplifier assembly to make sections which can be conveniently handled and transported.

Mechanical Design

Figure 1 shows the Porto-Arc Projector disassembled for transportation. First on the left is the pedestal-amplifier assembly, which is about the size of a large suitcase of conventional proportions. As is usually the case where a piece of apparatus closely resembles a familiar article of everyday life, the pedestal-amplifier has quickly come to be called, "the suitcase." Out of deference to the Society's Nomenclature Committee we shall refrain from use of the term hereafter in this paper.

The second item from the left in Fig. 1 is the portable loudspeaker regularly used with RCA Model 400 16mm Projectors. The third item is the dual-range arc lamp, and next is its associated rectifier for converting a-c line power to the low-voltage direct current required for proper operation of the arc lamp. The fifth and last item is the projector mechanism; reel arms and small accessory items are mounted within its housing. The heav-

Presented on October 8, 1953, at the Society's Convention at New York by J. J. Hoehn and A. J. Cardile (who read the paper), Radio Corporation of America, RCA Victor Div., Engineering Products Dept., Camden 2, N.J., and Ralph A. Woods, Hopkins & Woods, Martinsville, Ind.

(This paper was first received October 7, 1953, and in revised form Dec. 24, 1953.)

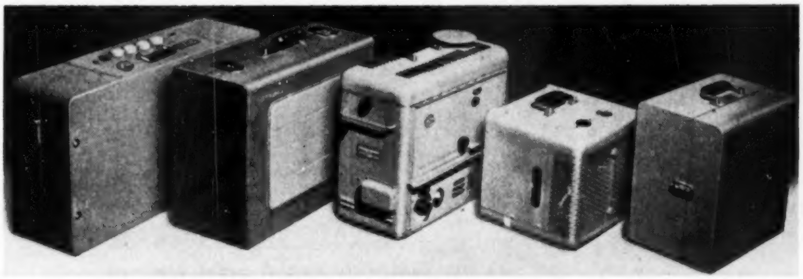


Fig. 1. The RCA Porto-Arc 16mm Projector is complete in five cases.

iest items are the pedestal-amplifier and the rectifier, which weigh about 60 lb each due to the inevitable weight associated with transformers of adequate performance characteristics.

Figure 2 shows the Porto-Arc Projector set up and operating. The projector mechanism and the arc lamp lock firmly together in correct optical alignment by means of guide pins, locating holes, and an aircraft-type cowl fastener. This feature was considered to be essential in a machine intended not only for portable service and professional projection, but also for operation by relatively inexperienced personnel. The assembled mechanism and lamp rest on the upper surface of the pedestal-amplifier case as shown, supported by the rear arc-lamp feet and by the movable front pins of the tilting device incorporated in the case. The pedestal legs are splayed a considerable degree laterally and longitudinally to provide excellent mechanical stability for the complete projector.

The pedestal-amplifier assembly has separate compartments to contain its demountable legs and the interconnecting cables, and it also incorporates the 5° tilting mechanism in the front operated by a fold-in crank. Adjustable legs accommodate the projector optical axis to existing projection room portholes and "up" or "down" projection angles. All interconnecting cables are provided with suitable plug connectors of a variety of types to prevent incorrect connections. In other words, if the plug on a cable end fits a given socket, it is the right plug for that socket.

Amplifier

Figure 3 is an interior view of the pedestal-amplifier case with the control panel removed to show the amplifier chassis. The amplifier incorporates

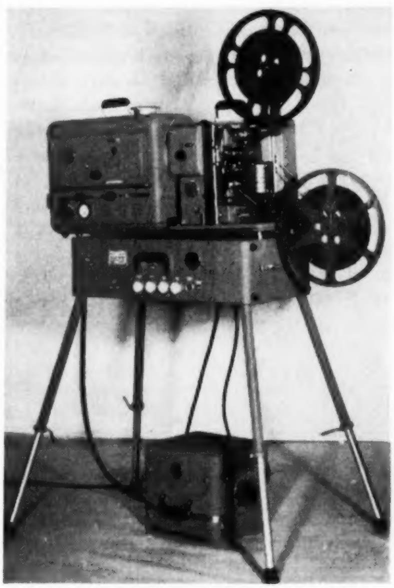


Fig. 2. RCA Porto-Arc set up in operating position.

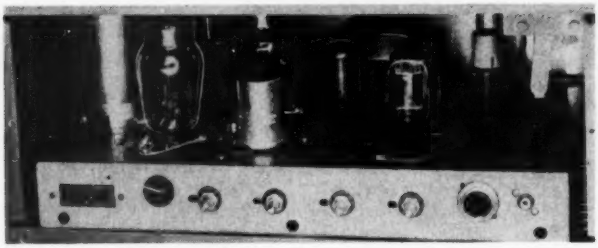


Fig. 3. Pedestal-amplifier case with control panel removed to show amplifier chassis.

the same type of high-frequency exciter lamp oscillator and tilt-type tone control used in RCA Model 400 16mm projectors, but the power output has been increased to 25 w for the larger audiences which can be served with 16mm arc projectors. There are individual mixer-type volume controls for the film sound channel, record player and microphone. The main power circuit to the projector enters via the magnetic circuit breaker at the left end of the amplifier chassis. Its time constant allows for the arc-striking current surge, but it opens before a thermal line fuse of equivalent rating will blow. Accidental overloads therefore operate a protective device at the projector location, and not at some possibly distant or inaccessible point. This feature, along with the automatic optical alignment of lamp and projector mechanism, was felt to be of importance in a machine capable of being operated, on occasion, by nonprofessional personnel.

Fig. 4. Rear view of pedestal-amplifier showing connections.

Figure 4 is a back view of the pedestal-amplifier case with the cable access door open. The two shielded-cable jacks at the left are for the projector mechanism phototube and exciter lamp circuits, respectively. The phototube circuit is triple-shielded to prevent interference pickup from the relatively strong fields existing around the arc circuits. The phone jack and pair of terminals to the left of it are both the loudspeaker output circuit from the amplifier so that either temporary or permanent connections can be made. The multiterminal strip at the right allows the output impedance to be changed to match the characteristics of the loudspeaker equipment being used. The output circuit from an RCA MI-35102 Magnetic Reproduce Kit installed in the projector mechanism may be connected to either the microphone input circuit, if both photographic and magnetic sound tracks are to be run, or to the phototube circuit jack in the rear if magnetic tracks only are to be reproduced.

Projector Mechanism

Figure 5 is a close-up of the projector mechanism. Except for certain modifications and additions required by the arc application, it is the same as has been used for some years in RCA Model 400 16mm projectors. Visible in the figure just above the picture gate assembly is the head of the cowl-lock

fastener which locks the mechanism to the lamp. Below and to the left is the theatrical-type framer control knob which shifts the moving film with respect to the aperture, and directly below it is the speed-shift control which changes the film speed from 24 frames/sec to 16 frames/sec. The motor switch is at the bottom of the control panel.

Since it is impractical to interlock the projector motor and lamp power circuits as is done in incandescent lamp projectors, it was considered essential that the RCA Porto-Arc Projector incorporate an automatic film-speed operated fire shutter to protect the film in the event of accidental film stoppage. By careful mechanical design, it proved possible to combine this function with that of a hand-operated "dowser" for keeping the light off the screen until the start of picture action. A centrifugal clutch was added to the regular picture shutter hub, and this clutch, via suitable linkage details, lifts an auxiliary shutter or "dowser" blade whenever the mechanism film speed exceeds 14 frames/sec, and provided the manual control lever for it is unlatched. This lever is visible in Fig. 5 just to the left of the framer control and may be identified by its horizontal knob. A simple notch in the lower edge of the lever provides the latched-shut feature. Slightly lifting the knob and pulling outward on it opens the dowser/fire shutter, but it

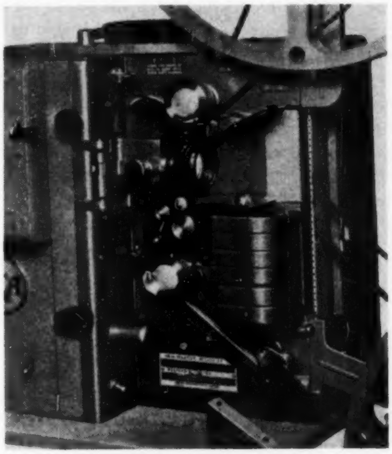


Fig. 5. The 16mm. Projector Mechanism.

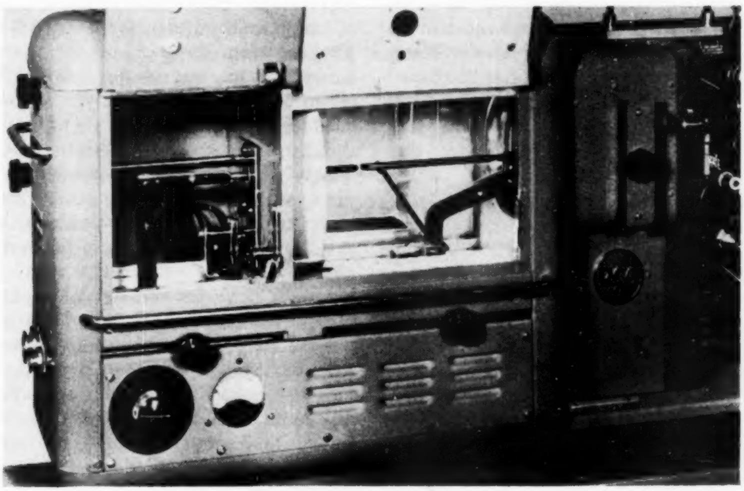


Fig. 6. The projector's arc lamp.

will not stay open unless the mechanism film speed exceeds 14 frames/sec as noted. Below this speed gravity forces in the linkage pull the blade closed, and it stays closed until the control lever is again manually lifted to unlatch it.

The housing for the 3450-rpm centrifugal blower normally associated with the projector mechanism's drive motor has been modified to provide strong cooling air blasts for the condenser lens, heat filter and picture aperture. Since the blower speed is the same at either 16- or 24-frame film speeds the cooling action is likewise the same, but of course the longer dwell time of the film in the aperture at the slower speed does call for the use of the heat filter for nearly all films being projected at this rate.

Arc Lamp

Figure 6 shows the arc lamp with the operating-side door open and with the cover for the feed-ratio pulleys removed. The relatively small, compact housing design is made possible by the selection of a combination reflector-condenser optical system. In the Porto-Arc Projector the length of the lamp has been further reduced by mounting the condenser lens in the projector-mechanism housing. Many design details result from manufacturing experience gained in the production of Hopkins & Woods "Sup-R-Arc" lamps for 35mm film projection, which were marketed also under other brand names by various 35mm equipment manufacturers.

The lamp is designed to operate with either the standard 30-amp, 28-v Pearlex carbon trim, or with a new 10-amp, 50-v trim. The 30-amp trim, without heat filter in place and with the optical system adjusted for 70% side-to-center distribution, delivers 1600 lm, using the two-blade 80° shutter normally supplied, and an $f/1.6$ lens. The 10-amp trim under the same conditions delivers 850 lm, which is in the order of twice that available from ordinary incandescent-lamp 16mm projectors. One 30-amp trim lasts 56 min, which accommodates a 2000-ft reel at 16mm sound speed. By contrast, the 10-amp trim burns 2 hr 15 min, which accommodates 4000-ft reels, though special feed and take-up facilities, which are being designed, are required. It is felt that this relatively long operating time without need for intermissions will eventually find considerable application, particularly in the foreign field where single-machine theater operation is common. The greater light output, as compared to presently used incandescent-lamp projectors, should materially improve the picture quality in such situations.

In Fig. 6 the outer edge of the elliptical reflector or mirror shows approximately in line with the left edge of the heat shield on the opened door. It is $7^1/_2$ in. in diameter and is mounted on a vertical baffle within the arc lamp by a three-point, spring-seated suspension. The center of the mirror is over 3 in. behind the arc to reduce fogging tendencies from arc gases. Two control knobs extending to the back of the arc lamp from the reflector's spring-mounted support frame provide tilt and training adjustments for uniform illumination of the projector-mechanism aperture. The working distance of the mirror alone is 25 in., but for the combination of mirror and condenser the working distance is less than 17 in. The optical speed of the combination is approximately $f/1.6$, which matches well with the speed of the fastest projection lenses customarily used. The condenser lens is situated about 13 in. from the mirror and is made of heat-resistant glass. It not only performs the optical function noted, but also effectively serves as a barrier to prevent cooling air currents from disturbing the arc. The condenser lens is mounted in a pull-out carriage visible in Fig. 6 just above the RCA monogram. It can thus very easily be inspected and cleaned when necessary.

Other items of interest visible in Fig. 6 are the positive-carbon holder and

carbon-tip guide, which are designed to obstruct the minimum possible light from the reflector. To the rear of the mirror supporting baffle is the negative-carbon holder, and just below it may be seen the mercury interlock switch actuated by the lamp door. For maximum operator safety it disconnects the arc rectifier from the power-supply circuit as the door is opened.

When the lamp is in operation the two carbon holders are moved slowly toward each other within the lamp base by their supporting carriages, which ride on two longitudinal feed screws. The carriages may be manually positioned along the screws for arc trimming and striking by means of the control knobs operating in the slots just below the door opening. Stops for the carriages cause the feeding action to cease when carbons burn down to stubs 2 in. long, thus preventing accidental damage to holders and tip guides. The ends of the feed screws protrude through the rear of the lamp housing as shown and support double-groove spring-belt pulleys. Moving the belt from one set of grooves to the other changes the negative/positive feed ratios to suit the relative burning rates of the two different carbon trims for which the lamp is designed.

The feed screws are driven by a specially wound d-c series motor connected to the arc circuit via an arc-current operated relay so that feeding action does not begin until the arc is struck. This effectively prevents accidental freezing of the carbons if power is inadvertently left on without striking the arc. The series motor circuit includes the average feed-rate control rheostat shown just to the left of the arc-current ammeter. In addition to the normal series motor-type field windings, the feed motor carries an additional field winding through which the arc current passes. The combined forces of the resultant fields provide a very effective stabilization action for the burning arc; for example, if the arc current tends to rise, say because the line voltage has gone up a few volts, the feed motor slows down so the arc gap lengthens slightly to bring the current back to the former value. The reverse action occurs if the current tends to fall. Small changes in burning rates due to nonuniform carbon composition are also compensated to a considerable extent by this stabilization action.

Figure 7 is another close-up of the arc lamp with the condenser carriage pulled out to show the heat filter. Also visible in this view is the rigid-tip guide for the negative carbon. The filter-glass strips are carried in an auxiliary holder which is easily slipped in or out of mating guides on the condenser carriage as shown. Experience to date has shown that with the degree of aperture cooling provided it is possible to run nearly all color films safely at 30-amp operation without the heat filter because they are relatively transparent to the longer-wavelength radiant energy. The heat filter is usually required for black-and-white films unless they happen to be of rather low density. The filter is essential for all types of film when operating at the projector's 16 frames/sec film speed, but is not usually required for sound-speed 10-amp lamp operation.

At the top of the lamp in Fig. 7 the ventilation chimney shows. It incorporates a scoop-shaped inner section, extending downward just above the arc to the edge of the light beam, which serves as a collector for the carbon electrode combustion products produced by the burning arc. The chimney assembly pulls out for cleaning; the dust washes off easily in cold running water.

Two openings are visible in the heat shield on the inner surface of the opened lamp door in Fig. 7. The larger opening is provided with heat-resistant dark glass for observation of the burning arc. The smaller opening is the port through which light from the arc enters the mirror assembly of the lamp's "arcoscope" on the outer door surface. Referring to

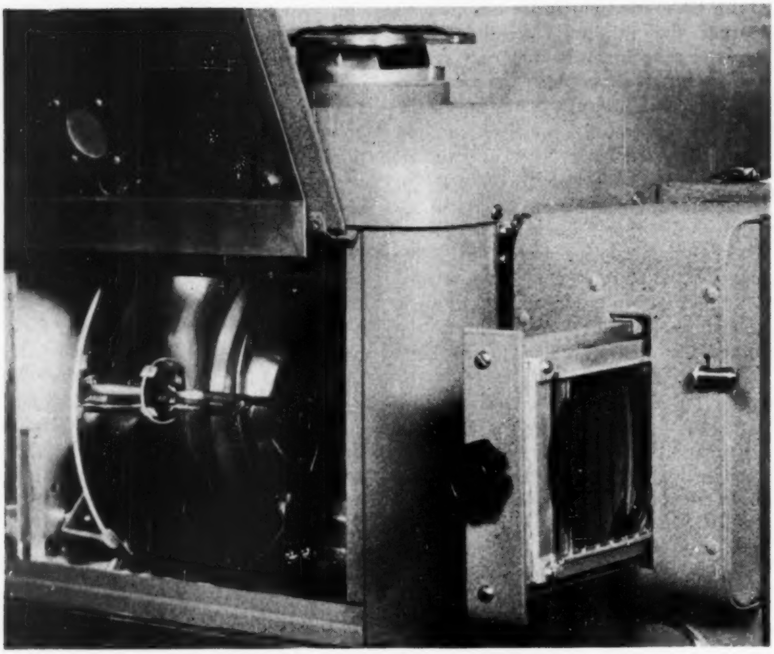


Fig. 7. The projector's heat filter design.

Fig. 2, which shows the door closed, the mirror assembly is seen just above the observation port, and it throws images of the brilliant carbon tips to the white screen directly below it. During initial testing of the lamp and projector mechanism the position of the burning arc with respect to the mirror is manually adjusted for maximum light output consistent with approximately 70% side-to-center light distribution on the screen. Lines are then scribed on the arcoscope screen marking the corresponding carbon-tip positions, and these lines become the references for subsequent lamp operation. As a rule, mirror characteristics are within tolerances which permit mirror replacement without scribing new reference lines, but alignment and focusing are simple operations easily carried out if necessary.

Figure 2 also shows the 30-amp rectifier in place under the pedestal-amplifier. The 10-amp rectifier is identical in exterior appearance. These rectifiers are used to convert alternating current from the power line to direct current required for proper operation of the arc. The 30-amp rectifier uses two standard 15-amp gas rectifier tubes; the 10-amp rectifier uses two 6-amp tubes. Both rectifiers are provided with primary tap switches to accommodate varying line voltage and load conditions.

Adaption for 3-D Projection

So far this paper has described single-machine setups of the RCA Porto-Arc 16mm Projector. Two-machine setups, with simultaneous, solenoid-operated change-over of picture and sound, are easily effected using conventional auxiliary equipment. Another type of two-

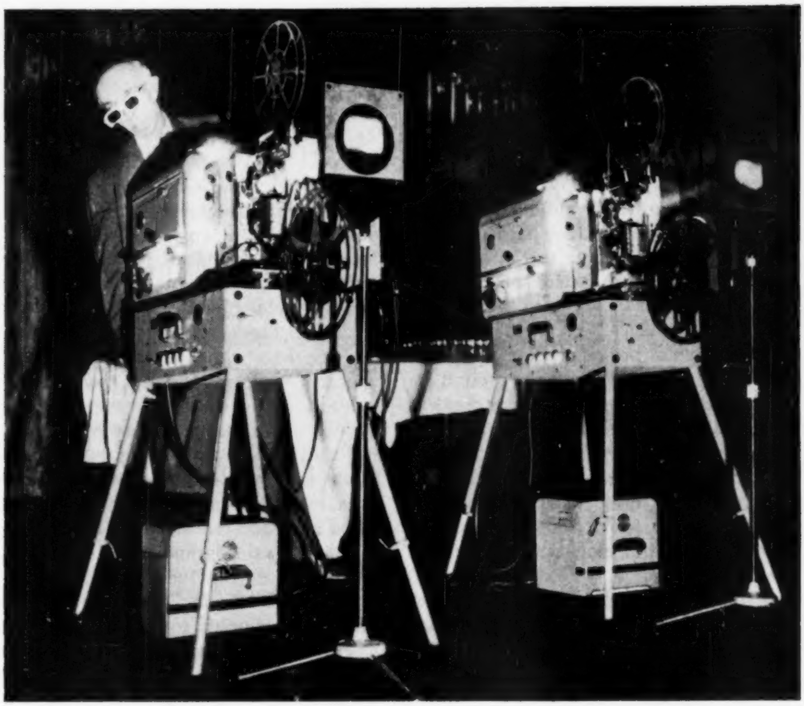


Fig. 8. RCA Porto-Arc 16mm Projector adapted for 3-D projection (photo courtesy Chicago Sun-Times), operated by George Karr of Local 110, Chicago Moving Picture Operators Union, IATSE, during demonstrations in July 1953.

machine setup involves the interconnection of two 16mm projectors to run exactly in step for the projection of "3-D" motion pictures by the double-film system. Mechanical interlock was considered and rejected as being impractical for equipment which must be readily transportable from one location to another. Complete selsyn (self-synchronous) drive systems of the type used to interlock studio recording and camera equipment would be satisfactory from the performance viewpoint, but tend to be heavy, complex and costly. Experience in the 35mm theater equipment field indicated that a modified type of selsyn interlock drive, in which the regular projector motors are retained to supply the needed driving power, with auxiliary selsyn coupled motors performing only the interlock function, gives entirely satisfactory results for projection. The auxiliary selsyn motors are reasonable in size and cost, and are relatively easy to couple into the regular projector-drive arrangements. This type of interlock drive system was therefore selected for the application of the RCA Porto-Arc Projector to 16mm 3-D projection, where its high light output is of extreme value in overriding the fairly large light losses inherent in the use of polarizing projection and viewing filters.

The 3-D version of the Porto-Arc Projector mechanism is provided with an extended base and enlarged rear cover to support and house the auxiliary selsyn drive motor. This motor is coupled to the main projector driveshaft and to the regular projector induction drive motor by means of sprockets and a toothed synthetic rubber "timing" belt. Motor circuits are carried from one projector of a pair to the other by means of cables and coded plugs capable of being inserted only into the proper mating receptacles. Facing the screen, the righthand projector of a pair normally has the most clearance around its operating position, so the master controls are installed on this machine. They consist of a master switch for simultaneously starting the two regular projector-drive motors, and a "lock-in" switch for the selsyn motor circuits to permit single-machine operation when desired.

Proper selection of timing-belt sprocket ratios provides for automatically correct phasing of the two film-transport movements after disconnection and reconnection of the interconnecting cables, once the initial phasing is carried out. This is accomplished by energizing the selsyn interlock circuits with the drive motors at rest, and then rotating the loosened sprockets on the selsyn motor shafts to bring the two movement claws as closely as possible to exactly the same points in their travel cycles, after which the sprockets are again tightened on the motor shafts. It is obviously necessary also that the shutter timing on the two projectors be identical, and that the framer settings be at least approximately so, though experience indicates that with the theatrical-type framing provided in RCA projectors, small vertical misalignments in the projected 3-D pictures can be compensated by framing without excessive deterioration in projected 3-D picture quality.

To facilitate threading the two prints of a 3-D film into the machines with the frames synchronized, the regular induction drive motors are provided with double shaft extensions and external handwheels so that the film transport movement can be brought manually to full claw protrusion for threading. With the selsyn "lock-in" switch closed, turning the handwheel on either machine operates both movements, which provides a ready check on the interlock action. As a matter of passing interest, it should be pointed out that the modified selsyn interlock drive system described does not provide absolutely fixed film speed since the main drive power is still supplied by the induction drive motors. The instantaneous speed stability is felt to be slightly better due to the larger mass of the coupled rotating components however, and of course all speed variations due to belt slippage are eliminated by the use of the timing-belt drives.

At the convention a special 3-D film produced by Raphael G. Wolff Studios was projected to show the potentially important applications of 3-D 16mm films in industrial, advertising and educational fields. At the moment it is anyone's guess as to whether or not 16mm 3-D entertainment films will ever be used in quantity. There can be no doubt, however, that 16mm 3-D films for selected applications, properly photographed and projected with adequate brilliancy, will enjoy well-deserved success for they provide the greatly enhanced realism and usefulness necessary for progress in any communication medium.

ABRIDGMENT

The Kinetics of Development by Vanadium Salts

By L. J. FORTMILLER and T. H. JAMES

This abridgment has been prepared for the Journal readers as a supplement to "Development of Motion-Picture Positive Film by Vanadous Ion," by A. A. Rasch and J. I. Crabtree, in the January 1954 Journal, pp. 1–10.

The rate of development of a motion-picture positive film by vanadous ion was measured at various temperatures, concentrations of vanadous and vanadic ion, and concentrations of acid and bromide ion. A special apparatus was employed which permitted continuous measurement of the developing silver during the course of the reaction. This apparatus was a modification of that described by Tuttle and Brown (*Jour. SMPTE, 54:* 149–160, Feb. 1950). The reaction chamber was made of Plexiglas, and the change of density in the developing film was measured continuously by means of infrared radiation passing through the reaction chamber and the film. This radiation was collected and measured by an IP22 photoelectric multiplier tube connected to an amplifier which fed a variable voltage Brown recorder. The readings on the recorder were converted to fixed-out density or metallic silver by means of calibration charts. The developer was stored and used in an atmosphere of nitrogen.

For a particular developer composition, the rate of image development follows a first-order equation to good approximation; i.e., the density, D, obtained in time, t, is given by the equation:

$$D = D_{\infty}(1 - e^{-kt}),$$

where k is the first-order constant. Development rates determined at various temperatures follow the Arrhenius equation; i.e., the logarithm of the rate is a linear function of the reciprocal of the absolute temperature. The temperature coefficient is 1.5 for an interval of 10 C, and the apparent activation energy is approximately 6.5 kcal/mole.

The dependence of development rate on the concentration of vanadous ion was determined for a solution which contained 0.38 M HBr, 0.05 M H_2SO_4, and varying amounts of vanadium. The total vanadium-ion concentrations were varied from 0.025 M to 0.10 M, and the vanadous-ion content from 21% to 99%. Over this range, the development rate is directly proportional to the concentration of vanadous ion and independent of the concentration of vanadic ion. The rate does not depend on the redox potential of the solution. The effect of acid was determined for a solution containing 0.083 M vanadium, of which 87% was in the form of vanadous ion, and sulfuric acid concentrations varying from 0.32 M to 3.3 M. The rate of image development shows little dependence on the acid concentration, but the rate of fog formation

Abridgment of Communication No. 1555 from the Kodak Research Laboratories by L. J. Fortmiller and T. H. James, Research Laboratories, Eastman Kodak Co., Rochester 4, N.Y. The full version appeared as a preprint of the Royal Photographic Society Centenary International Conference on the Science and Applications of Photography, London, September 1953.

increases with increasing acid concentration. The effect of bromide ion added as KBr was determined for the solution containing 0.32 *M* sulfuric acid. The rate of image development increases slightly with increasing bromide-ion concentration in the range 0 to 0.35 *M*. The rate of fog formation decreases with increasing concentrations of bromide over the range 0 to 0.06 *M*, but subsequently passes through a minimum and then increases. The increase may be attributed to the solvent action of the higher concentrations of bromide ion on the silver bromide.

Development by vanadium probably follows the simple chemical equation:

$$V^{++} + AgBr \rightarrow V^{+++} + Ag + Br^{-}.$$

The experimental results suggest that the rate-controlling step is the diffusion of the vanadous ion. The rate of development of liquid (uncoated) emulsion is very high compared with that of the coated emulsion, so that diffusion through the gelatin layer probably is the dominant factor in determining the rate of development of coated film. The first-power dependence of rate on vanadous-ion concentration and the low temperature coefficient, both, are in accord with this interpretation. The fact that the rate of image development increases slightly with increase in bromide-ion concentration is just the opposite from the expected result if the rate were controlled by a chemical reaction, but is in accord with expectation if the rate is controlled by diffusion. Increase in bromide-ion concentration increases the negative charge on the grain surface and should increase slightly the rate of diffusion of the positively charged vanadous ion in the immediate neighborhood of the grain. At vanadous-ion concentrations greater than 0.10 *M*, the rate of development no longer is simply proportional to concentration, and the diffusion process evidently becomes more complicated.

American Standards PH22.21, —.22, 1953, 8mm Motion-Picture Film, Usage in Camera and Projector

Published on the following pages are revisions of two American Standards: Z22.21-1946, Emulsion Position in Camera for 8mm Silent Motion-Picture Film; and Z22.22-1947, Emulsion Position in Projector for Direct Front Projection of 8mm Silent Motion-Picture Film. The revisions are purely editorial in nature, consisting of a change in title and use of the word "rate" in place of "speed" in paragraph 2.—*H.K.*

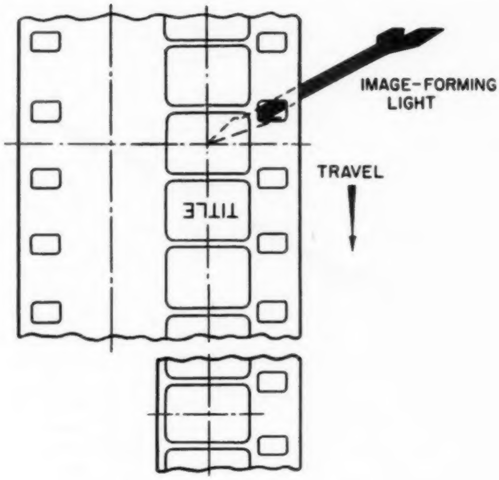
American Standard

8mm Motion-Picture Film Usage in Camera

ASA
Reg. U.S. Pat. Office

PH22.21-1953

Revision of Z22.21-1946
*UDC 778.53



Film as seen from inside the camera, looking toward the camera lens.

1. Position of the Emulsion

1.1 Except for special processes, the emulsion shall be toward the camera lens.

2. Rate of Exposure

2.1 The normal rate of exposure shall be 16 frames per second.

Note: This standard differs from the 1941 and 1946 editions solely in editorial modifications.

Approved December 17, 1953, by the American Standards Association, Incorporated
Sponsor: Society of Motion Picture and Television Engineers

*Universal Decimal Classification

American Standard

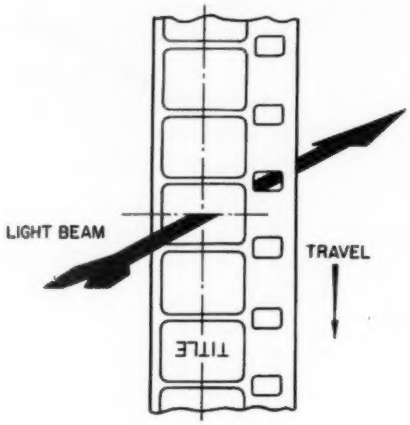
8mm Motion-Picture Film Usage in Projector

ASA
Reg. U.S. Pat. Office

PH22.22-1953

Revision of Z22.22-1947

*UDC 778.55



Film as seen from the light source in the projector.

1. Position of the Emulsion

1.1 Except for special processes, the emulsion shall be toward the projection lens.

2. Rate of Projection

2.1 The normal rate of projection shall be 16 frames per second.

Note: This standard differs from the 1941 and 1946 editions solely in editorial modifications.

Approved December 17, 1953, by the American Standards Association, Incorporated
Sponsor: Society of Motion Picture and Television Engineers

*Universal Decimal Classification

Printed in U.S.A.
ASA1½M354

Price, 25 Cents

75th Convention — 60-Year Old Flickers — Television

Members at the Spring Convention will have a chance to see some of the earliest motion pictures. The Library of Congress and the Academy of Motion Picture Arts and Sciences have been instrumental in the successful conversion to 16mm film of some of the interesting old paper contact prints that were deposited with the Copyright Office of the Library of Congress between 1894 and 1912. During that period there was no provision in the copyright law referring specifically to motion pictures, but there was a provision for the registration of copyright claims for photographs. Producers therefore protected their works by registering paper prints of their 35mm films. The films themselves have in most cases disintegrated or been lost in other ways, so that these paper prints constitute a unique record which now for the first time becomes available for practical demonstration.

Through the courtesy of the Academy a number of these reprints will be shown during the Convention sessions. Originally, the motion picture was considered to be a gimmick for clearing vaudeville houses. It was believed that people could not stand more than 10 minutes of the "flickers." Let's hope that this interesting application of the art may possibly serve to keep sessions running to schedule.

A representative group of these early titles includes *Gatling Gun Crew in Action*, *The Corset Model*, *The Way to Sell Corsets*, *The Ex-Convict*, *The Girl at the Window*, *An Englishman's Trip to Paris from London*, *Great Baltimore Fire*, *Latina*, *Contortionist*, *International Contest for the Heavyweight Championship*, *Squires versus Burns*, *Automobile Race for the Vanderbilt Cup*, and *The Inn Where No Man Rests*.

Some or all of these will be shown as opportunity permits. In the main, however, early flickers or later motion-picture short subjects will be chosen in relation to the subjects of sessions. Other early films, especially some in color, are also being made available through the helpful offices of Margaret Herrick, Secretary of the Academy of Motion Picture Arts and Sciences.

The entire motion-picture short subjects program for the 75th Convention is under Motion-Picture Chairman Jack McCullough, Motion Picture Association of America, 28 W. 44 St., New York 18. Convention authors and members are asked to send Jack advice about what they would like to see on the program.

Program Chairman Aiken reports that the sessions and subjects as announced in the December *Journal* have been revised slightly in that: (1) there will be High-Speed Photography Sessions on Thursday afternoon and Friday morning; and (2) Television Sessions on Friday morning and afternoon will include, in addition to the papers announced earlier, the following:

"CBS Color Television Staging and Lighting Practices," by Richard S. O'Brien, CBS, New York.

"Color Kinescope Recording Methods," by E. D. Goodale, NBC, New York.

"Continuous Film Scanner," by Otto Wittle, Camera Works, Eastman Kodak Co., Rochester, N.Y.

If you do not have reservations at Washington, refer to p. 183 of the February *Journal* for information about the Hotel Statler for May 3–7.

The Convention Notice containing the Advance Program with brief abstracts for the papers has been mailed to the membership. Additional copies are available from Society headquarters.

SMPTE Officers and Committees: The roster of Society Officers and the Committee Chairmen and Members were published in the April 1953 *Journal*. A new roster is being prepared for the April 1954 *Journal*.

Engineering Activities

New Engineering Vice-President, Axel G. Jensen, faced as his first official task the appointment of all engineering committee personnel who, according to the Society's Bylaws, serve for a two-year term. Chairmen may be reappointed for a second term and members may be reappointed for any number of terms. Under these rules eight former chairmen, seven new chairmen, and some three hundred committee members, of whom 5 to 10% are new to committee work, were appointed. A complete roster of engineering committees will be published as usual in the April *Journal*.

Dissolution of the Test-Film Quality Committee was approved at the January 1954 meeting of the Board of Governors. This committee was established about three years ago to help improve quality control of test films sold by the Society, but the need for it has since disappeared. Its dissolution recognizes that Fred Whitney, Staff Test-Film Engineer, is ably executing the quality-control function.

The Board similarly approved **Dissolution of the Theater Engineering Committee.** Through the years specific aspects of its original functions were siphoned off into other more specialized committees such as Screen Brightness, Film-Projection Practice, and Sound, giving it finally an official field of interest limited to such items as theater carpets and air conditioning, valuable in themselves but covered adequately by those industries. The technical revolution in the motion-picture industry temporarily revived the committee, providing urgent need for a theater-screen survey that was launched in May 1953 and finished late in the year. With the conclusion of the survey (see the Report in the January 1954 *Journal*) it appeared reasonable and desirable to dissolve the committee.

The two committees on **Films for Television and Television Film Equipment** have now been combined into one, chaired by Gentry Veal and named simply **Television Committee.** Its new scope, given below, is a combination of the two previous ones.

The close interrelationship between the work of the two committees together with the rather large overlapping of personnel provided a natural basis for this union. It is anticipated that this step will make for greater efficiency in committee activity and will speed the development of specifications for a color-television test film, the major project before the committee.

Scope: To make recommendations and prepare specifications on all phases of film equipment used in television broadcasting. Further, to make recommendations and prepare specifications on all phases of the production, processing and use of film made for testing of and transmission over a television system.

A comprehensive, definitive **Motion-Picture Nomenclature** has been a long sought but little realized goal. Some two years ago an Interim Committee on Nomenclature was formed (reported on p. 549 of the June 1952 *Journal*) in an attempt to further this work. A spirited effort was made but the immensity of the job was too much for any one committee and it too fell by the wayside. But the goal is still bright and a new effort is now being made to reach it in a series of short, discrete steps via a coordinated assignment of work to each of the engineering committees. In his letter to the chairman of each committee Mr. Jensen stated, "It has been decided to adopt a procedure similar to that followed in other technical societies; namely, to let each technical committee be responsible for the definition of terms covering its own field. As a first step in this work, it is felt that the technical committees should insure the existence of proper definitions for all technical terms used in already existing American Standards sponsored by the SMPTE." The responsibility for correlating this nomenclature activity has been assigned to the Standards Committee. The actual correlating function is to be handled by a Nomenclature Subcommittee headed by Calvin Hotchkiss.—*Henry Kogel*, Staff Engineer.

The Color Plates in the December Journal

A good deal of interest has been shown in the color plates that accompanied the paper "Improved Color Films for Color Motion-Picture Production" by W. T. Hanson, Jr., and W. I. Kisner, published in the December 1953 *Journal*. The color plates were supplied by Eastman Kodak ready for binding into the *Journal*. They were made by the Kodak Ektalith process, which has been developed by the Eastman Kodak Co. to meet the demand for low-cost color printing in quantities of only a few thousand.

The process is based on the use of 35mm Kodachrome slides, although the same methods are applicable to all sizes and types of originals. Three colors are used for printing instead of the usual four. (For the *Journal* illustrations an additional printing plate was used to print the figure titles in black.) The color separation negatives are printed onto a Kodak Ektalith Sheet, which is a metal plate coated with a layer of a surface-hydrolized cellulose ester, sensitized with a solution of ammonium bichromate. The smooth, grainless surface of this plate, combined with the use of the right type of inks, makes possible the sharp printing of 266-line halftones. (Most periodical illustrations are as coarse as 110- or 120-screen.)

Most of the Ektalith color illustrations are printed on a Multilith Duplicator; however, the techniques used may also be applicable to larger-press operation. All registration, with the exception of a final small adjustment of the press, is achieved by purely mechanical means.

Fuller information about the process can be found in the following:

Walter Clark, "Cellulose acetate offset printing plate," Proceedings of the 2nd Annual Meeting, Technical Association of the Lithographic Industry: 115–118, 1951.

H. C. Stachle, "A simplified system of color printing," Proceedings of the 4th Annual Technical Meeting, Technical Association of the Graphic Arts: 143–150, 1952.

Pacific Coast Meeting

A meeting of the Section was held on December 15, 1953, at the Paramount Studios in Hollywood. Attendance was 285, although space limitation made it necessary for members to make reservations.

Carl Lesserman of Telemeter Corp. discussed the technical and economic phases of the Telemeter system of subscriber television, particularly with relation to the experimental telecast recently made at Palm Springs, Calif.

A method of subjective stereophonic reproduction from optical sound tracks was described by Louis Mesenkop, Assistant Sound Director at Paramount, who demonstrated the method with selections from *War of the Worlds*. Comparisons were shown on single and double photographic tracks switched to the three reproducing channels by means of the Dorsett system of control tracks in the sprocket-hole areas.

Loren Ryder, Sound Director and Head of Engineering at Paramount, gave a technical and economic appraisal of current technical advances, with particular relationship to the effects they may have on the future of motion pictures and television.—*E. W. Templin*, Secretary-Treasurer, Pacific Coast Section, c/o Westrex Corp., 6601 Romaine St., Hollywood 38, Calif.

SMPTE Lapel Pins

The Society has available for mailing its gold and blue enamel lapel pin, with a screw back. The pin is a ½-in. reproduction of the Society symbol—the film, sprocket and television tube—which appears on the *Journal* cover. The price of the pin is $4.00, including Federal Tax; in New York City, add 3% sales tax.

Book Reviews

Die Lichtverteilung im Grossen in der Brennebene des photographischen Objektivs

By Dr. Ernst Wandersleb. Published (1952) by Akademie-Verlag GmbH., Berlin NW7, Schiffbauerdamm 19. i–xiv + 125 pp. 49 illus. 11 tables. 6¾ × 9¾ in. $4.80.

The author investigates the distribution of light in the focal plane of a photographic objective and especially the factors contributing to the intensity variation from the center of the picture to the border.

The factors contributing to the decrease of illumination are: First, the $\cos^4 w$ law, which gives the natural decrease of light. The angle w in this formula is the angle which the principal ray of the bundle forms with the axis on the object side. Second, there is the influence of distortion where it is found that barrel distortion has a favorable effect and pincushion distortion an unfavorable effect with respect to the amount of light received. Third, there is the vignetting factor, which comes from the fact that the apertures of the single lenses may not be sufficiently large, so that some of the light coming from an off-axis point may be cut out. Fourth and fifth, there are reflections at the glass-air surfaces and absorption in the glass which may further reduce the amount of light emerging from the objective.

The author investigates in great detail all these factors and their frequently erroneous treatment in the literature. Of special interest to the reader may be the chapter in which the author discusses and refutes the claim of the inventors of the so-called "cycloptic" systems, which were thought to overcome the $\cos^4 w$ law of light decrease because of the fact that the exit pupil in such a system is at infinity.

The book contains a large amount of theoretical and experimental material with respect to the subject. In the later chapters the author discusses also the "false light," which is not image-forming, but which may very well change the image contrast considerably. He calculates, in particular, the amount of light which comes from double reflection at two glass-air surfaces. Of great interest is the author's suggestion for separating false and image-forming light by looking at the image through a cystoscope, which, because of its length, "sees" only the direct light.

The book contains the analysis of the light-loss in a large number of typical optical systems. The excellent drawings and photographs deserve special mention and the publisher is to be commended for the clear print and the quality of the illustrations.—*Max Herzberger*, Research Laboratories, Eastman Kodak Co., Rochester 4, N.Y.

Electronic Measurements, 2d Ed.

By Frederick Emmons Terman and Joseph Mayo Pettit. Published (1952) by McGraw-Hill, 330 W. 42 St., New York 36. i-xiii + 683 pp. + 8 pp. Author Index + 15 pp. Subject Index. 448 illus. 6 × 9 in.

The first edition, *Measurements in Radio Engineering*, has been so extensively revised and expanded that *Electronic Measurements* may more reasonably be considered a new book than a second edition. *Electronic Measurements* is no compendium of electronic measuring techniques nor is it intended as such. It is, rather, a well-organized textbook devoted to the measurement of electrical quantities and constants in the frequency range of direct current up through the microwave region with the unaccountable exception of the subaudio range. The chapters on "Laboratory Oscillators" and "Generators of Special Waveforms" are unusually good and add much to the value of this book for reference uses. The figures are numerous — they average about two to every three pages — and very well done.

To write a book on measurements without straying too far into the closely allied field of instrumentation is a difficult task. The authors have succeeded admirably in treating fundamental measuring techniques without undue concern with instrument details. There are, of course, omissions. An ever present need to conserve text space militates against the mention of infrequently used techniques such as, for example, the measurement of voltage with the electrostatic meter or the alternating-current potentiometer. Specific footnote references might well be used to draw attention to those methods of limited practical usefulness which are illustrative of basic principles.

Members of this Society, with their special interests in the audio and video fields, will note a number of omissions. There is no mention of wave filters or of the precautions necessary when measuring their transmission characteristics although transmissions lines are discussed at some length. The chapter on waveforms has a good discussion of the fundamental-suppression method of distortion measurement but no reference to the fundamental-balance method. Several techniques of wave analysis receive well merited attention yet the method of simultaneous analysis by tuned circuits or tuned reeds goes unmentioned. The old reliable "gain-set" method of measuring amplifier gains is not described though similar techniques of lesser precision are explained. Rather surprising in view of the space devoted to the SMPTE method of intermodulation measurement is the omission of the cross modulation method (XM) of measuring distortion, for the XM test is also an American Standard. The CCIF method described is, of course, the equivalent of the XM method; both have the same limitation, as normally used, of measuring only even order distortion.

These sample criticisms are of minor importance in relation to the book as a whole. This reviewer, having very limited knowledge of microwave techniques finds the sections dealing with microwave measurements very satisfactory. A specialist in microwave techniques would probably find the coverage of audio and video measurements equally satisfactory. As a text for use in conjunction with classroom or laboratory work *Electronic Measurements* is highly recommended. The engineer working in fields outside of his specialty will find this text a valuable source book. It is replete with references, many of them to recent publications. This is an especially desirable feature for one can always trace the development of a subject backward in time if a good recent reference is available.—*W. K. Grimwood*, Research Laboratories, Eastman Kodak Co., Rochester 4, N.Y.

Television, A World Survey
Published by UNESCO. 175 pp. $1.75.

This report covers 45 countries and territories. In 20 of these, public broadcasts are on the air; 8 are carrying out technical broadcast experiments; and in the other 17, governments or private organizations are taking active steps to introduce television. The study gives detailed information on the history of television in each country surveyed, its structure and organization, its source of revenue, the technical facilities which are available or planned for the future, programming and reception, the number and characteristics of transmitters, and other subjects such as color television and the training of personnel for new stations. A final section describes United Nations television activities.

A comparative table of countries having regular or experimental broadcasts lists the number of television stations in operation, the estimated number of receivers, the potential audience, date of first broadcast and other information. Another table deals with countries where technical experiments are under way, and a third table lists countries planning the introduction of television. Copies can be obtained from the UN Bookshop or from Columbia University Press, 2690 Broadway, New York 27.

Television Factbook, No. 18
Published (January 15, 1954) by Radio News Bureau, Wyatt Bldg., Washington, D.C. 374 pp. $8\frac{1}{8} \times 11$ in. $3.00. 1954 TV map 43×29 in. $1.00.

The latest in this semiannual reference series brings up to date statistical tables summarizing 1953 and preceding years' FCC, PIB and other reports on network and station revenues, expenses, etc.; set and tube production, sales and shipments; and financial data on leading TV-radio-electronic manufacturers.

Also included are the usual data on TV stations (150 more since the last edition—reviewed in September 1953 *Journal*), networks and personnel, and directories of advertising agencies, national sales representatives, TV program sources, FCC, attorneys, consulting engineers and other consulting services, major electronic laboratories, community antenna systems, theater television installations and firms, market research organizations, trade associations, labor unions, and bibliographies of the literature and periodicals in the field.

The accompanying map shows all TV cities, existing and projected AT&T and private network facilities, all cities peculiar to the TV allocation plan, and all other cities over 10,000 population.

3 SOUND MAGAZINES, to be noted since the Journal of the Audio Engineering Society was initiated a year ago, are:

International Sound Technician, an illustrated monthly published by International Sound Technicians, Local 695, IATSE, has now been appearing since early in 1953. Devoted to de-

velopments and activities in the field of sound recording, the contents cover a very wide range of material, from technical papers through more popular "how to" articles to news items about events and personalities in the industry. Subscription rates are $2.50 per year or $5.00 for three years.

Revue du Son is a French monthly journal concerned with every aspect of professional sound recording and reproduction. Compiled by a distinguished board of editors and under the technical direction of Lucien Chretien the material is on a high technical level and representative of the latest progress in French research and industrial development. Each issue contains a substantial editorial by the editor, Maxime de Cadenet, and the technical papers are grouped under such headings as: Sound Reproduction, Sound Recording, Sound Films, Acoustics, Supersonics, Sound Systems, Circuits, Design. There are also book reviews, notices of new products, and news items about the industry. Subscriptions, which can be obtained from Editions Chiron, 40 rue de Seine, Paris 6, France, are 2100 francs per year, for 11 issues.

Tape and Film Recording, the first number of which appeared in December 1953, is a new illustrated bimonthly published by Mooney-Rowan Publications, Inc., Severna Park, Md. It is aimed primarily at the amateur tape-recorder enthusiast and is made up of "how to" articles, New Products, Questions and Answers, Consumer Reports on new equipment, etc. A year's subscription (6 issues) costs $2.00.

Photo-Lab-Index, 14th Lifetime Edition, published by Morgan & Lester, 101 Park Ave., New York 17, is the 1954 issue of this standard reference work. All phases of photography and related fields are included in 24 separate sections: Ansco, Ilford, Gevaert, Dufaycolor, Du Pont, Eastman Kodak, Haloid, Film Data, Filter Data, Illumination, Photo Papers, Weights and Measures, Chemicals, Cine Data, Darkroom, Color Data, Optics, Defects in Negatives and Prints, Transparencies and Slides, Copying, Photomechanical Processes, Bibliography, Photo-Words, Television. Photo-Lab-Index has 1348 pages in a looseleaf binder and sells for $17.95. Quarterly supplement subscriptions are available direct from the publishers only, at $3.00 per year.

Slides and Opaques for Television is a new pamphlet prepared by the Eastman Kodak Co. for inclusion in the Kodak Photographic Notebook. It describes the various types of photographic stills that are used in television and discusses the problems of safe area, tonal range, restricted range, lighting, subject, photographic processing, distribution of tones, color sensitivity and visibility standards involved in the preparation of artwork. Information is also given on copying equipment, exposure, lighting and handling of materials in the actual making of opaques and slides. Members can obtain copies of this pamphlet by applying to the Motion Picture Film Dept., Eastman Kodak Co., Rochester 4, N.Y.

Current Literature

The Editors present for convenient reference a list of articles dealing with subjects cognate to motion picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington D.C., or from the New York Public Library, New York, N. Y., at prevailing rates.

American Cinematographer

vol. 34, Oct. 1953

"Penthouse" 4-Track Sound Reproducers (p. 479) *R. Lawton*

MGM's Variable Wide Screen Projection Lens (p. 484) *F. Foster*

Simplified Single-Film System for 3-D Exhibition (p. 485) *A. D. Roe*

Film Splicing Without Cements or Adhesives (p. 486) *L. A. Herzig*

The Pan Cinor-Variable Zoom Lens for 16mm Cameras (p. 490) *A. Rowan*

vol. 34, Nov. 1953

Extension Tubes in Cine Photography (p. 545) *J. Forbes*

Wide Screen for 16mm Presentations (p. 558)

vol. 34, Dec. 1953

Is 3-D Dead . . . : (p. 585)

Paramount's "Lazy-8" Double-Frame Camera (p. 588) *J. R. Bishop and L. L. Ryder*

Electronic Recording of Pictures on Tape (p. 596) *A. Rowan*

Closeup Photography with 16mm Single-film Stereo Systems (p. 598) *E. Wildi*

Animated Movies with Paper Cutouts (p. 600) *G. W. Cushman*

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vol. 1, no. 3, July 1953

A Variable-Speed Distributor System for Synchronizing Out-of-Sync Pictures and Sound Tracks (p. 241) *H. M. Tremaine*

The Amplifier and Its Place in the High-Fidelity System (p. 246) *H. H. Scott*

Bild und Ton

vol. 8, Dec. 1953

Herstellung von Schwarzweiz-Kopien von Agfacolor-Negativen (p. 354) *W. Brune*

Die Gestaltung des Farbentwicklungs-Laboratoriums (p. 355) *C. Michel*

Farbaufnahmen auf Agfacolor-Umkehrfilm (T) bei Leuchtstofflampenlicht (p. 359) *G. Wendel*
Entwicklungsstand der Bildprojektoren und Bildtonanlagen für 16-mm-Film in der Sowjetunion (p. 365) *G. Pierschel*

British Kinematography

vol. 23, no. 3, Sept. 1953
The Application of Television for Underwater Use (p. 58) *C. Hirsch, G. T. Syminton and N. R. Phelps*

vol. 23, no. 4, Oct. 1953
Water Effects (p. 86) *R. L. Hoult*
The Production of Trailer (p. 98) *E. Harris*

vol. 23, Nov. 1953
The Practical Problems of 3-D Presentation (p. 115) *G. E. Fielding*
2-D and 3-D Trends in the Current Cinema (p. 124) *R. J. Spottiswoode*

Electronics

vol. 26, Nov. 1953
Color-Television Converter for Cable Networks (p. 132) *J. G. Reddeck and H. C. Gronberg*

vol. 26, Dec. 1953
Sound-Projector Amplifier for 16-mm Motion Pictures (p. 194) *J. A. Rodgers*

vol. 27, Jan. 1954
Camera Adapter for TV Receivers (p. 141) *L. E. Flory, W. S. Pike and G. W. Gray*

General Electric Review

vol. 56, Nov. 1953
Color Television — Today and Tomorrow (p. 19) *W. R. G. Baker*

Home Movies

vol. 20, Dec. 1953
"Panavision" . . . New Wide Screen System (p. 510) *H. Provisor*

International Photographer

vol. 25, Dec. 1953
CinemaScope Makes Under-Water Debut (p. 5) *T. Gabbani*

International Projectionist

vol. 28, Oct. 1953
Film Industry Eyes New Stereo Sound (p. 7) *T. L. Burnside*
Stereoscopic Projection and Photography. III. History and Projection Techniques (p. 10) *R. A. Mitchell*
CinemaScope Wrecks Records (p. 16) *J. Morris*
Lens Chart for Wide Screens (p. 17) *M. D. O'Brien*

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Recent Projection Advances in Europe (p. 7) *R. A. Mitchell*
Film Splicing for 3-D and CinemaScope (p. 11) *J. Morris*
RCA's "Magnetic Movies" Portend New Industry Revolution (p. 22) *F. Hodgson*

An Improved Carbon Lamp for 3-D and Wide Screen (p. 29) *E. Gretener*
Panaphonic System is Shown on Coast (p. 37)

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Neue Wege zum Stereo-Schmalfilm bei Halbbildanordnung (p. 249) *H. Atorf*
Entwicklung und Stand der Magnettonband-Technik (p. 252) *Jarczyk*
Betrachtungen über Schmalfilmaufnahmeobjektive verschie dener Brennweiten (p. 254) *W. Albrecht*
Philips-Schmaltonfilmprojektor 16mm Cinema Typ EL 5000 (p. 256)

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Hochfrequenzkamera für 3,500,000 Bilder je Sekunde (p. 287) *H. Hintze*
Askania-Projektoren für 3-D-und Cinemascope-Filme (p. 289) *L. Busch*
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3D . . . Its Progress and Its Prospect (p. 12)
A Functional Setting for the "Wide-Screen" Picture (p. 18) *B. Schlanger*

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Colour According to the Rules and . . . Against Them (p. 287) *J. Lauwers*

RCA Review

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Particle Counting by Television Techniques (p. 546) *L. E. Flory and W. S. Pike*

Aperture Compensation for Television Cameras (p. 569) *R. C. Dennison*

Radio & Television News

vol. 50, Oct. 1953

TV Tube Substitutions (p. 50) *W. H. Buchsbaum*

Color TV (p. 51) *W. R. Feingold*

New TV Intermittent Checker (p. 56) *J. Racker*

Know Your 1954 General Electric TV Receivers (p. 63) *J. Najork*

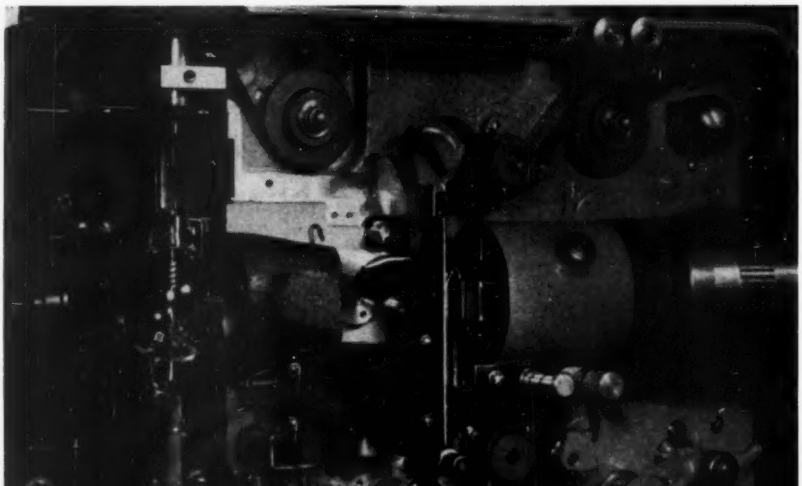
New Products

Further information about these items can be obtained direct from the addresses given. As in the case of technical papers, the Society is not responsible for manufacturers' statements, and publication of these items does not constitute endorsement of the products.

A new light source, claimed to be five times brighter than conventional bulbs and designed to function simultaneously as light and shutter, has been announced by De Vry Corp., 1111 W. Armitage Ave., Chicago, Ill. This development makes possible a shutterless motion-picture projector. It is also intended to meet unusual demands for brightness level such as are met with in 3-d projection and color television.

Ordinary projectors operate with 48 light fields in 24 frames/sec of film, giving each frame two light fields, with the shutter responsible for a loss of up to 50% of the available light. Since the new source eliminates the shutter, all the available light can be used. It consists of a xenon gas, quartz-enclosed arc lamp, specially designed to give intermittent fields of light to each frame as the film passes through the projector. Instead of the ordinary two fields, however, each frame receives five fields. The film is synchronized so that the pulldown on each frame occurs during the 4.5 msec of darkness between each flash. A standard shuttle is used for the pulldown. A full description of this new development is to be given at the SMPTE Spring Convention in Washington, D. C., May 3–7.

A new **station identification slide** is offered by Loucks & Norling Studios, Inc., 245 W. 55 St., New York 19. As the illustration shows, the call letters, channel number, address and any other information that may be wanted are fitted into



a resolution pattern. The price of a 2 × 2-in. slide, made up to include the customer's information, is $100. Additional slides cost $5.

RTMA television resolution charts available from Loucks & Norling are:

Slides (Mounted in glass)	
2 × 2 in., image 0.85 × 1.13 in.	$ 3.75
2 × 2 in., image 0.92 × 1.22 in.	3.75
3¼ × 4 in., image 2.25 × 3.0 in.	5.00
Motion-Picture Films (safety stock)	
35 mm Silent (no sound-track signal), 250 ft	40.00
35 mm 400-cycle signal optical sound track, 250 ft	50.00
16 mm Silent, per unit of 100 ft	17.50
16mm 400-cycle signal optical sound track, 100 ft	25.00
Film Strips (safety stock, 35 mm)	
Unit of 40 frames [2½ ft in length)	4.75

The Angenieux Retrofocus 35mm Lens, a new lens for television, is announced by Ponder & Best, Telelens Division, 814 North Cole Ave., Hollywood 38, Calif. Featuring a 64° angle of view, this high-resolution lens is intended to fill the need for a quality lens of short focal length. It is supplied in a focusing mount with iris diaphragm and having an effective aperture of f/2.5.

Employment Service

These notices are published for the service of the membership and the field. They are inserted for three months, at no charge to the member. The Society's address cannot be used for replies.

Positions Wanted

Wanted, Motion-Picture Industrial Engineer: 8 yrs planning plant expansion and improvement projects of film laboratories, including equipment procurement, contracting, expediting, bill-of-materials control, machine design, material handling, floor-plan layout, utilities. Familiar with cinematography, sensitometry, color principles, printing problems, mfg. processes. MIT-trained in mech., elec., indus. engineering. Esp. interested in Service Dept., producer liaison, or TV applications. Phone or write: F. L. Bray, DuArt Film Laboratories, 245 W. 55 St., New York City, PLaza 7-4580.

Motion-Picture Television Technician: 10 yr intensive skill and know-how related to 16-35mm cinematography, animation, recording (optical, tape, disk), editing, laboratory processing practice (black-and-white, color); also kinescope recording techniques; self-reliant; inventive; relocate if required; write: CMC, c/o Penning, 435 E. 74th St., New York 21, N.Y.

Motion-Picture Laboratory Technician: 3½ yr experience as motion-picture laboratory technician in black-and-white and color. Emphasis has been on color processing with both Ansco and Eastman color films. Experience in managing production and supervising personnel. Desire position that can make the most of above experience. Write; Bryan Allen, 812 Vermillion St., Gary, Ind.

Motion-Picture Cameraman: Retiring from Naval Service. 15 yr experience in camera operation, printing, processing, adm. and supervision of production crews. Desires position in TV, educational or industrial field, inaugurating a motion-picture program. Available after May 1954. Prefer West Coast. Write: W. W. Collier, 422 W. Jackson Ave., Warrington, Fla.

Electronics Engineer: B.S.E.E., 3 yrs chemical engineering, 2 yrs graduate work in physics. Currently working on Masters Degree. Engaged in gaseous electronics research, experienced in design and development of electronic instrumentation, installation and operation of automatic recording temperature control systems, vacuum system technique, maintenance and repair of all types of electronic equipment. 4 yrs retail business experience. Possess ability to write clear, concise reports. Interested in

the motion picture, both artistically and technically. Desire position with organization in Los Angeles area preferably engaged in motion-picture production. Expect to be in Los Angeles area in late summer this year. Request interview. Member, IRE, SMPTE, Fla. & Nat. Soc. of Prof. Engs. Registered Engineer in Training State of Florida. Age, 28; unmarried. Write: Berel David Solomon, Box 274, Univ. Station, Miami, Fla.

Positions Available

Photographic Engineer: Wanted for design and development work involving application of film and associated equipment to monochrome and color TV systems. Prerequisites are BS or equivalent, and experience in at least one of the following motion-picture fields: (a) TV film applications, (b) processing laboratory design and operation, (c) camera and projector design or (d) sensitometry and densitometry. Please send résumé to Personnel Dept., CBS Television, 485 Madison Ave., New York 22, N.Y.

Sales Management Engineer: To head division manufacturing single optical track stereo sound system. Already adopted by major studio. Position requires knowledge of theater sound systems here and abroad. Reply to: Fairchild, Rm. 4628, 30 Rockefeller Plaza, New York 20, N.Y.

Engineer: To direct engineering of flying-spot TV projector with millisecond pulldown mechanism. Mechanism already developed and working. Reply to: Fairchild, Rm. 4628, 30 Rockefeller Plaza, New York 20, N.Y.

Wanted — Consultant technician: Thorough knowledge of Houston continuous double-head printer, Houston developing machines, Bell & Howell printers and Debrie Matipo step printer. Must put machines in running order and train operating personnel. Usual per day rate and plane fare to Puerto Rico. Address replies to R. J. Faust, Chief, Cinema Section, Dept. of Education, Commonwealth of Puerto Rico, Division of Community Education, P. O. Box 432, San Jaun, Puerto Rico.

Permanent Position: Open for versatile 16mm cameraman familiar with all phases of industrial production. Write McLarty Picture Productions, 45 Stanley St., Buffalo 6, N.Y.

Meetings

Radio Engineering Show and I.R.E. National Convention, Mar. 22–25, Hotel Waldorf Astoria, New York

Optical Society of America, Mar. 25–27, New York

The International Sound Track Recording Convention has been announced by the Association of Radioelectricians, 10 Ave. Pierre Larousse, Malakoff (Seine), France, to be held in Paris, April 5–10, 1954, on sound-track recording processes and their extension to other fields of application. Radio and television networks and the motion-picture industry will participate with technical papers, an exhibition of equipment, and tours of plants and technical centers. Problems of standardization will be discussed.

The Calvin Eighth Annual Workshop, Apr. 12–14, The Calvin Co., Kansas City, Mo.

International Symposium on Information Networks (information from Microwave Research Institute, Polytechnic Institute of Brooklyn, 155 Johnson St., Brooklyn 1, N.Y.), April 12–14, Engineering Societies' Building, New York

Society of Motion Picture and Television Engineers, Central Section, Spring Meeting, Apr. 15, The Calvin Co. Sound Stage, Kansas City, Mo.

75th Semiannual Convention of the SMPTE, May 3–7, Hotel Statler, Washington

Society of Motion Picture and Television Engineers, Central Section (with Western Society of Engineers), May 13

Society of Motion Picture and Television Engineers, Central Section (with Western Society of Engineers), June 10

American Institute of Electrical Engineers, Summer General Meeting, June 21–25, Los Angeles, Calif.

Acoustical Society of America, June 22–26, Hotel Statler, New York

American Physical Society, June 28–30, University of Minnesota, Minneapolis, Minn.

American Physical Society, July 7–10, University of Washington, Seattle, Wash.

Illuminating Engineering Society, National Technical Conference, Sept. 12–16, Chalfonte-Haddon Hall, Atlantic City, N.J.

Photographic Society of America, Annual Meeting, Oct. 5–9, Drake Hotel, Chicago, Ill.

American Institute of Electrical Engineers, Fall General Meeting, Oct. 11–15, Chicago, Ill.

76th Semiannual Convention of the SMPTE, Oct. 18–22, Ambassador Hotel, Los Angeles

77th Semiannual Convention of the SMPTE, Apr. 17–22, 1955 (next year), Drake Hotel, Chicago

The International Commission on Illumination is to hold its next international conference in Zürich, Switzerland, June 13–22, 1955 (*next year*). Offers of papers should be addressed to the Chairman of the Papers Committee (A. A. Brainerd), 1015 Chestnut St., Philadelphia 7. Manuscripts must be in the hands of the Central Bureau between Oct. 1 and Dec. 31, 1954.

78th Semiannual Convention of the SMPTE, Oct. 3–7, 1955 (next year), Lake Placid Club, Essex County, N.Y.

SUSTAINING MEMBERS

OF THE

SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS

Alexander Film Co.
Altec Companies
Ansco
C. S. Ashcraft Mfg. Co.
Audio Productions, Inc.
The Ballantyne Company
Bausch & Lomb Optical Co.
Bell & Howell Company
Bijou Amusement Company
Buensod-Stacey, Inc.
Burnett-Timken Research Laboratory
Byron, Inc.
Century Projector Corporation
Cineffects, Inc.
Cinéma-Tirage L. Maurice
Geo. W. Colburn Laboratory, Inc.
Color Corporation of America
Consolidated Film Industries
DeLuxe Laboratories, Inc.
De Vry Corporation
E. I. du Pont de Nemours & Co., Inc.
Eastman Kodak Company
Max Factor, Inc.
Federal Manufacturing and Engineering Corp.
Fordel Film Laboratories
General Electric Company
General Precision Equipment Corp.

- Ampro Corporation
- Askania Regulator Company
- General Precision Laboratory, Incorporated
- The Hertner Electric Company
- International Projector Corporation
- J. E. McAuley Mfg. Co.
- National Theatre Supply
- The Strong Electric Company

W. J. German, Inc.
Guffanti Film Laboratories, Inc.
Hunt's Theatres
Hurley Screen Company, Inc.
Kollmorgen Optical Corporation
Lorraine Carbons
J. A. Maurer, Inc.
Mecca Film Laboratories, Inc.
Mitchell Camera Corporation
Mole-Richardson Co.
Motiograph, Inc.
Motion Picture Association of America, Inc.

- Allied Artists Productions, Inc.
- Columbia Pictures Corporation
- Loew's Inc.
- Paramount Pictures Corporation
- Republic Pictures Corp.
- RKO Radio Pictures, Inc.
- Twentieth Century-Fox Film Corp.
- Universal Pictures Company, Inc.
- Warner Bros. Pictures, Inc.

Movielab Film Laboratories, Inc.
National Carbon Company

- A Division of Union Carbide and Carbon Corporation

National Cine Equipment, Inc.
National Screen Service Corporation
National Theaters Amusement Co., Inc.
Neighborhood Theatre, Inc.
Neumade Products Corp.
Northwest Sound Service, Inc.
Polaroid Corporation
Producers Service Co.
Projection Optics Company, Inc.
Radiant Manufacturing Corporation
Radio Corporation of America, RCA Victor Division
Reid H. Ray Film Industries, Inc.
Raytone Screen Corp.
Reeves Sound Studios, Inc.
S.O.S. Cinema Supply Corp.
SRT Television Studios
Shelly Films Limited (Canada)
The Stancil-Hoffman Corporation
Technicolor Motion Picture Corporation
Titra Film Laboratories, Inc.
Wenzel Projector Company
Westinghouse Electric Corporation
Westrex Corporation
Wilding Picture Productions, Inc.
Wollensak Optical Company